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EDITED BY A

FEW WELL-WISHERS TO KNOWLEDGE.

No. II.

THE CONNECTION

BETWEEN

PHYSIOLOGY

AND

INTELLECTUAL PHILOSOPHY.

SECOND EDITION ENLARGED.

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ADVERTISEMENT TO THE FIRST EDITION.

In complying with the wish of those friends who requested me to offer this Lecture to the Public, I am extremely anxious to serve what I believe and hope to be an increasing class of my countrymen. It is my strong desire to benefit those who, though eager for information, cannot afford much time or much money for the prosecution of philosophical inquiries. It is then to the intelligent artizan, who prefers the Mechanics' Institution to the poisonous atmosphere and contaminating society of the gin-shop: it is to the agriculturist and the tradesman who have discovered that an evening spent in the smoking-club is not productive of enjoyment equal to that derived from the perusal of such books as awaken a spirit of research in their children, that I dedicate this volume.

In revising it, I have been aided by the works of many eminent physiologists, and by the advice of many kind cotemporaries. Among the latter, I may reckon the Author of "*Philosophical Theories and Philosophical Experience*," to whose work, through the medium of a friend, I had access while

it was yet in manuscript, and whose object it has been, in common with some other of his intimates, to bring philosophy into a form that might benefit the mass of mankind, instead of being the mere luxury of a few learned men.

But to name the authors I have consulted, and the persons to whom I owe obligations, would be mere ostentation. It is enough to say that I have not knowingly neglected any source of accessible information. While I have striven to make these pages familiar and intelligible to all, I have never been led to adduce a doubtful in preference to a sounder theory, by the greater ease with which the more questionable doctrine might be expressed. At the same time I have avoided entering on any controverted subject; and therefore I have neither engaged with the interesting speculations of the phrenologists, nor with the excito-motory system of Dr. Marshall Hall, powerfully and attractively as it has been advocated by that philosopher, by Mr. Grainger, and other eminent physiologists.

J. Barlow.

London, January, 1842.

ADVERTISEMENT TO THE SECOND EDITION.

The little work of which a second edition is now presented to the public, originally formed one of the Friday Evening communications to the members of the Royal Institution of Great Britain. The short space of time allotted to these communications,—one hour,—necessarily limited the speaker in the treatment of his subject to the narrowest possible bounds, and the Editors conceive that the favor with which it has already been received will not be lessened by some addition to its contents, which will enable them to give a somewhat more expanded view of this most interesting part of physiology, as well as to notice any farther discoveries which may tend to throw light upon it.

The Editors of the "Small Books" have already had occasion to notice the almost unexpected success which has attended their undertaking: of course this excites a corresponding zeal to deserve it, and they flatter themselves that the increased quantity of letter-press in the later numbers of series will be such as to meet the wishes of those who before considered the price too high for the size of the books.

CONNECTION BETWEEN PHYSIOLOGY

AND

INTELLECTUAL PHILOSOPHY.

I.

1. There is probably no man, who ever thinks at all, who does not sometimes ask himself how that thought is accomplished; how he is so linked to, yet separate from, the exterior world; and how and why he is different from the tribes of sentient beings which surround him. He has seen the progress of human nature almost unlimited; yet a disease, the work of a moment, leaves this half godlike creature a helpless and unreasoning animal. He shrinks with a kind of instinctive horror from a state which would yet be the natural and happy one of many of those classes of sentient beings, and anxiously asks himself, "What then is his destination? What the ultimate object of his existence?" These are a few of those riddles of life, which, however little they may form the topics of general conversation, lie uneasily in the secret recesses of most men's minds; and if in our subject of this evening I can solve some of them, my hearers will probably not think their attention ill bestowed.

2. The earth, the water, and the air, are thickly peopled with various forms of living creatures: it is therefore desirable no less for the common intercourse of life than for scientific purposes, that these animated beings should be grouped together on some principle of mutual resemblance; accordingly, systems of classification have been in use from the very earliest periods. I do not now purpose to enter into the history or the comparative merits of these modes of classification; it is sufficient to select the one which I believe to be most philosophical, which I know to be best adapted to make my views intelligible, and which originates from the most eminent physiologists of our time. It is based on the difference of the *nervous system* in the respective classes, which is more and more developed in each, till it arrives at its final perfection in man.

a. *Crypto-neura*, the hidden-nerved.—*Rudolphi.**

This includes coral insects, madrepores, sea-anemones, sea-nettles, hydatids, flukes, some abdominal worms, &c.

In these animals,† "The neurine or nervous matter, if existing at all, being incorporated with the other tissues, cannot be demonstrated as forming a separate system."

b. *Nemato-neura*, the thread-nerved.—*Owen.*

This includes many of the infusorial and microscopic animalcules, and (what the ordinary observer is more familiar with) star-fishes, sea-urchins, &c.

In these animals there is usually found a thread-like ring round the gullet, from whence

* Beyträge sur Anthropologie, quoted by Jones, General Outline of Animal Kingdom, p. 6.

† Solly on the Human Brain, p. 5.

minute filaments occasionally proceed to other parts of the body.

c. *Homogangliata*, animals whose ganglia are symmetrically arranged.—*Owen.*

This division comprehends (together with less known animals) leeches, earth-worms, scolopendras, insects, scorpions, spiders, lobsters, crabs, &c. This division is characterized by having the nervous masses (*ganglia*) distributed over the body at regular intervals, corresponding to its well-defined segments.

d. *Heterogangliata*, animals in which the arrangement of the ganglia is not symmetrical.—*Owen.*

In this division are found barnacles, oysters, muscles, snails, cuttle-fish, &c.

In this large group of animals, that symmetrical arrangement of parts so conspicuous in the ray of the star-fish, the segment of the insect, &c., is no longer observable; and the nervous system is as irregular in its distribution as the organs which it supplies are disproportionate to each other in their size.

e. *Myelencephalia*, animals possessing a brain in a bony skull.—*Owen.*

This group requires no additional description at present; it comprehends fishes, frogs, reptiles, birds, mammalia, and at the head of these, Man.

3. It will be observed in the foregoing table that a nervous system has been traced in all animals (that is, in all beings that can feel and move), except in those comprehended in the division *a*. But it is extremely probable that this system also exists in the *cryptoneura*, although its presence has not yet been detected in them,* since they exhibit sensation

* Carpenter's Inaugural Dissertation, p. 76.

and voluntary powers. The nervous system consists,

1. Of nerves and irregularly shaped masses of nervous matter, called ganglia.
2. Of a prolonged cord of nervous matter both vesicular and fibrous, sheathed in its proper membranes;—or as some think, of a series of connected ganglia;—the whole protected by the vertebræ of the spine, which are hollowed to receive it.
3. Of a superadded brain, or, as some have considered it, a collection of ganglia connected with the organs of sense. This brain is always defended by a bony case, or skull. It is found only in the animals of division e.

4. The nervous matter which forms this complicated system is varied both in appearance, and most probably in function. It may be classed under two divisions, the vesicular and the fibrous. "The *vesicular* nervous matter is gray or cineritious in color, and granular in texture: it contains nucleated nerve vesicles,* and is largely supplied with blood. It is more immediately associated with the mind, and is the seat in which originates the force manifested in the nervous system. The *fibrous* nervous matter, on

* "The essential elements of the gray nervous matter are *vesicles*, or cells containing nuclei and nucleoli. They have been called nerve or ganglion globules. The wall of each vesicle consists of an exceedingly delicate membrane, containing a soft but tenacious, finely granular mass. The *nucleus* of the cell is generally eccentric, much smaller than the containing vesicle, and adherent to some part of its interior. Its structure is apparently the same as that of the outer vesicle. The nucleolus is a minute, remarkably clear, and brilliant body, also vesicular, enclosed within the nucleus. It forms a most characteristic and often conspicuous part of the nerve-vesicle." Todd and Bowman's Physiology, vol. i. p. 212.

the other hand, is, in most situations, white, and composed of tubular fibres, though in some parts it is gray, and consists of solid fibres. It is less vascular than the other, and is simply the propagator of impressions made upon it. When these two kinds of nervous matter are united together in a mass of variable shape or size, the body so formed is called a *nervous centre*, and the threads of fibrous matter which pass to or from it are called *nerves*. The latter are *internuncial* in their office: they establish a communication between the nervous centres and the various parts of the body, and *vice versâ*. The smaller nervous centres are called *ganglions:* the larger ones, the *brain* and *spinal cord*."*

5. When examined by the naked eye and the finger, a nerve is a soft, white, thread-like substance. In its course it resembles a leafless branch. It spreads out into small nervelets or filaments, and thus diminishes or increases in size according as it is traced *from* or *towards* the central cord or ring in which it originates. But when carefully viewed by the microscope,† each nerve is found to be a mere bundle of extremely small tubular filaments, containing a sort of half fluid pith. These are separately enclosed and connected together by a covering of a very delicate texture, and the whole is cased in a thin membranous sheath. These fibrils sometimes unite with, sometimes cross over each other, sometimes form new groups with detachments from other bundles, sometimes are twisted over each other: but in no instance does the minutest fibril so penetrate another that there can be a mixture of their component particles. Therefore, although the number of

* Todd and Bowman's Physiology, vol. i. p. 205.
† Carpenter's Principles of Physiology, p. 42.

nervous filaments is immense, there can be no confusion in the discharge of their functions. "The nerves appear to be formed after the same manner as the muscles, i. e., by the fusion of a number of primary cells arranged in rows into a secondary cell. The primary nervous cell, however, has not yet been seen with perfect precision by reason of the difficulty of distinguishing nervous cells, while yet in their primary state, from the indifferent cells, out of which entire organs are evolved. When first a nerve can be distinguished as such, it presents itself as a pale cord with a longitudinal fibrillation, and in this cord a multitude of nuclei are apparent." "According to Valentin's description, the following is the process of development of the nerve vesicles. In the very young embryos of mammalia, as the sheep or calf, the cerebral mass in the course of formation contains in the midst of a transparent blastema, transparent cells of great delicacy with a reddish-yellow nucleus. Around these primitive cells, which we find likewise formed after the same type in the spinal cord, a finely granular mass becomes deposited, which probably is at first surrounded by an enveloping cell membrane. At this early period of formation the primitive cell still preserves its first delicacy to such a degree that the action of water causes it to burst immediately."*

6. The functions of the nerves are various: experience has shown that the intervention of nerves is absolutely necessary; 1, to the continuance of animal life; 2, to the reception of sensation; and 3, to the production of movements in all the higher orders of animals; and from analogy it has been conceived that even if it have hitherto eluded observation,

* Todd and Bowman's Phys., vol. i. pp. 227, 228.

nervous matter does exist, even in the lower tribes; for organic life is possessed no less by the rooted zoophyte, which seems scarcely to have any consciousness of the exterior world, than by man. But the actions of man being all destined to be modified by his rational faculties, a more complex arrangement is requisite in his case, in order to bring the whole system into harmony. The functions of animal life, therefore, are carried on by a machinery which, though capable of acting alone, is yet so connected with the organs of the higher faculties, as to be placed in great measure under subjection to them.

7. At the head of this machinery stands that set of ganglia, and their connecting nerves, which is known to anatomists as the *sympathetic, ganglionic, or tri-splanchnic* system*, or sometimes, in older writers, as *the great intercostal nerve.* This is found extending from the base of the skull in a double chain of ganglia on each side of the vertebral column, interiorly as regards the body, and passing within the ribs towards the lower part of the trunk. Throughout its course, numerous nerve fibres are thrown out to supply the viscera both of the thorax and abdomen, and "branches attach themselves to the exterior of arteries, forming very intricate plexuses, which entwine around them, hederæ ad mo-

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* So called from σπλαγχνα, viscera: "We may with de Blainville consider it as divisible into two parts, one placed in front of the spine (prævertebral) composed of plexus and ganglia (semilunar and cardiac), whose branches are distributed to the primary organs of digestion and circulation: the other consisting of two knotted cords, extended along the whole length of the spine, communicating with the prævertebral plexus on the one hand, and with the cerebro-spinal nerves on the other."—*Quain and Wilson's Anatomy of the Nerves*, p. 4.

dum" (Scarpa). The ganglionic system is closely connected with both the brain and spinal cord at its offset, and keeps up a communication with this last, through the whole of its course, by means of a white and a gray filament, which both pass between each ganglion and the anterior root of each spinal nerve. Thus the series of nerves and ganglia which send out branches to every part connected with respiration, nutrition, and circulation, are united by interchange of fibres with the spinal cord, and are thus connected with the brain.

8. The sympathetic system may be considered as the chief agent in the maintenance of animal life: for the maintenance of life depends on nutrition, and nutrition consists in the constant assimilation of fresh substance to supply the place of what is thrown off in the continual state of movement and change which constitutes what we term good health. The analysis of animal bodies gives about four elementary substances (hydrogen, oxygen, carbon, and nitrogen), which are found in like manner to compose the air that we breathe and the food that we eat: but no human art has succeeded in compounding from them the smallest particle of organized matter, and we remain in great measure ignorant of the exact nature of the changes which convert food and air into the texture of the body. All that we can know, therefore, is, that the *sympathetic system* is the immediate instrument of effecting these changes, and that by some yet undiscovered properties of its nerves and ganglia, inanimate matter is made to share the life of the part to which it is assimilated. It is remarkable that, unlike all other nerves, those connected with the system we are describing, are neither susceptible of sensation so long as they continue in a healthy state, nor do they require an effort

of the mind to keep them in action. The organs supplied by the sympathetic nerves are equally unlike the other members of the body in properties and in structure. For the limbs are disabled for a time by fatigue after long-continued exertion, whereas the heart, lungs, &c., whose vital action is sustained by this system, never require rest, although always in exercise. As it is essential to our existence that the operation of these organs should be unintermitting, it is most fortunate for us that they so rarely excite our notice; for we should never enjoy a moment's repose, were it necessary to keep up the circulation, respiration, &c., by a constant attention to them. And though this system exacts so little from our intellectual powers, rejects the control of our will, and rarely disturbs us by exciting a sensation, it nevertheless does strongly sympathize with our bodily and mental feelings. The heart, whose unwearied and unfelt movements are the result of its influence, throbs uneasily during the period of anxious and fearful expectation, and so forcible is the impulse given by powerful emotion, as sometimes to rupture the parts by a rush of blood. I have already touched on the connection of nerves by which this is effected, and it must be noticed again when I come to treat of instinctive emotions.

9. Such then is the apparatus of mere *organic* life. But this life requires support and defence in all but the very lowest division of the animal kingdom. The *crypto-neura* are, indeed, without exception, inhabitants of fluids; they therefore depend for subsistence on the casual nutriment that may be floated towards them: their bodies, too, like plants, may be mutilated to a great extent, and yet preserve their vitality, as they are capable of reproducing a

severed part: but it is not so with the higher orders of animals: with them dismemberment is fatal, or at best irreparable. These also have to select or to seek their food, and must be warned against the approach of danger: a further apparatus of nerves is accordingly provided, by which they can take cognizance of external objects, and these nerves are usually termed the *nerves of the senses.* I shall not stay to inquire in how large a degree the inferior orders of animals possess them; in the higher they consist of smell, sight, hearing, taste, touch, and perhaps,—for on this point physiologists are not wholly satisfied,—of general sensation.* For all but the two last named,

* A curious case recorded by the late Dr. J. Cheyne seems to favor the opinion that there may be a set of fibres conveying to the brain a sense of general sensation independent of the sense of touch. "We know an instance," says he, "of a remarkable delusion, arising from complete loss of feeling in the left side of the body, caused by an attack of palsy, which first originated, and then fatally terminated in apoplexy. In the morning the individual maintained that he had two left arms, and when we tried to convince him that he was under a misconception, he promptly offered to produce the supplementary arm. 'There it is,' said he, patting his left shoulder with his right hand. 'Well then,' it was asked, 'where is the other?'—On which, turning round his head with great alacrity to show it, he seemed much disappointed when he could discover but one arm, vehemently declaring that 'there were two, in the night.'" *Cheyne's Essays*, p. 60. Here there must have been general sensation in the arm, or the patient would not have felt that he had an arm at all—but when in the night he felt but could not see that he had an arm, and on touching the surface of the palsied limb with the other hand, was sensible of no impression, he naturally supposed the real arm to be existing behind or beside the dead substance which he touched. Between sleeping and waking even in health we do not always reason, and here probably the reasoning power was somewhat disturbed by the lesion of the brain. If there should be a sense of this kind, it would account for the fact that *pain* is felt in palsied limbs which are insensible to touch; as well as for those cases of insanity or idiocy where the sense of touch remains, but that of heat, or the pain ensuing from a burn, is lost.

if two they be, a system of nerves within the skull, and in direct communication with the brain, is provided; whereas, the sense of touch being distributed over the whole body, is conveyed to the common centre of sensation by an immense number of nervous filaments, which either plunge into the spinal cord through small openings in the bone provided for them, and thus find their way to the brain, or are immediately connected with it.

10. Thus far I have described the machinery of life and sensation only, but it is further necessary that the living sentient animal should have the means of preserving his existence, of seeking pleasure, and of avoiding pain. This is accordingly provided for by another set of nerves, *the nerves of voluntary motion.* The operation of these nerves however is, in respect of direction, opposite to that of the nerves of sensation. It is by means of the latter that constant communications from all parts of the body *to* the brain are carried on. The nerves of motion on the contrary issue *from* the brain, and convey its mandates to whatever part it would control. This constant interchange somewhat resembles what is carried on between the provinces and the capital by the mail-trains. The nerve of sensation, like the train which conveys letters to the capital, receives continual contributions from the tracts which it passes through, until the whole, compressed into the smallest compass, is delivered at the central post-office: and in like manner the nerve of motion, like the out-train, keeps sending forth its district mails at each successive station, until the most distant one is delivered at the terminus.

11. Thus we have three distinct systems of nervous mechanism in the living body, each dependent on the other, namely,

I. The unconscious involuntary nerves of life;
II. The conductors of external and internal feelings to the brain;
III. The conveyers of volition *from* the brain to the organs fitted for action;

which are respectively termed the *sympathetic*, the *sensitive*, and the *motor* nerves.

12. I have already described the Sympathetic System (1) as a series of ganglia with connecting nerves, whose office it is to supply the nervous energy by which the functions of circulation, secretion, &c., are unconsciously carried on. The composition of these nerves differs considerably from that of the spino-cerebral system, being formed chiefly of a gray gelatinous fibre, not found in any great abundance elsewhere. These fibres seem to form an intermediate substance between the vesicular, and fibrous nervous matter; (4.) for they contain among them "numerous cell nuclei, some situated in the centre of the fibre, others adhering to either edge, and frequently exhibiting distinct nucleoli."—"The mode of connection of the gelatinous fibres with the elements of the nervous centres," say the authors of the work from which I have already quoted, "is, as yet, quite unknown. They are found in considerable numbers in what are called the roots of the Sympathetic, or the communications of that nerve with the spinal nerves; and it has been supposed by Valentin that they are continuous with certain elements of the vesicular nervous matter."*—That vital power by which the common functions of nutrition and reproduction are carried on, has been termed by Professor Liebig,—"vegetative life," and in the acknowledged obscurity which hangs over the *modus operandi* of

* Todd and Bowman's Phys., vol. i. p. 212.

the nervous power, it may be allowed to throw out as a hint for future consideration, that the cell nuclei so largely interspersed among the gray gelatinous fibres of the sympathetic ganglia and nerves, have no small analogy with the primitive forms of the vegetable world. In both kinds of organic life, the cell seems to be the first and simplest form assumed by incipient organization;* in both the granules contained within the cells have been seen in motion,† although no shock has been communicated to them externally. Whence this motion arises is not easy to decide, but movement being produced, the first condition of assimilation, and consequently of the maintenance of life, is there. And here a wide field opens itself:—electricity has been considered, nay, may we not say, proved, by Prof. Faraday to be merely a phenomenon of matter, the consequence of molecular movement communicated by chemical change; and Prof. Matteucci of Pisa has proved by a series of experiments that animal muscle is capable of taking the place of metals in forming a galvanic

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* See Carpenter's Physiology, p. 15.

† "Such motions are either of a uniform and rhythmical kind, or they are apparently irregular and oscillating. Those of the former kind are familiarly known in the vegetable kingdom by the Cyclosis which takes place in the oblong cells of Chara. The granules which may be seen in motion are quite passive, and are carried along by currents within the cell. Motions of the latter kind have been seen by Schwann among the granules contained in the cells of the germinal membrane of the hen's egg, as if occasioned by an endosmotic current through the wall of the cell. This membrane is the seat of active change, the development and growth of new cells destined for the evolution of the textures of the embryo. A molecular motion of the same kind may be seen in the very minute granules which occupy the cells of the membrane of black pigment on the choroid coat of the eye. Whether this goes on during life is of course impossible to say, but the conditions for its production are undoubtedly present." *Todd and Bowman's Phys.*, vol. i. p. 59.

current:* and heat is generated where electrical action is excited. No series of experiments has yet *proved* that these isolated facts of science have any intimate relation to each other, but an inquiring mind cannot avoid asking the question, have they not?—Is not the movement which is excited within the primitive cell,—though perhaps merely the result of endosmose,—the first step in a series of phenomena, each resulting from the other till the most complex machinery of organic life is developed and kept in action.† Whether the nucleated cells found so plentifully scattered among the gray fibres of the sympathetic system may generate and propagate such movement, of course is not, perhaps never may be, ascertained; but if it were so, it would be one more instance to add to the many that modern science has

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* "The organic actions of muscle by which the electrical current is developed may be compared to the inorganic phenomena attending its production from the decomposition of metals. When a plate of metal, immersed in an acidulated fluid, is oxidized by the oxygen of the water, and then dissolved in the acid, we admit that an enormous quantity of electricity is developed during this action.—The metal acted upon in the artificial arrangement is represented, in the phenomenon of the muscular current, by the muscular fibre; the acidulated fluid is the arterial blood. The surface of the muscle, or any other conducting body, not muscular fibre, but which is in contact with the muscle, represents the second plate of metal, which does not suffer chemical action, and which serves only to form the circuit. The direction of the muscular current is precisely such as it should be supposing the current to be as we have represented it, due to chemical action taking place in the interior of the muscle." (The direction of the current is from the interior to the exterior.) The above is quoted from Matteucci's communication to the writers of the work on Physiology already quoted, vol. i. p. 383, and there the experiments are detailed by which Prof. Matteucci proved the facts above stated.

† Both electricity and heat are present in the germination of seeds;—are not both, possibly, modifications of molecular movement?

discovered, of the beautiful simplicity of means by which the mightiest effects are produced, where PERFECT KNOWLEDGE and PERFECT POWER have been employed in conjunction.

13. We have now to consider another system of nerves differing both in function and appearance from the foregoing: i. e., the spinal. These issue from each side of the spinal cord, to the number of thirty-one pairs, but each individual nerve is attached to the cord by two sets of filaments (15) which from their respective situations are termed the anterior and posterior roots of the spinal nerves.* The posterior root is distinguished by a ganglion found on it near its point of junction with the cord; the anterior passes over this ganglion, but sends no fibres into it, although both at their exit from the vertebral column are wrapped in the same common covering: but presently after, the fibres of each root cross over each other, and the two great branches into which this compound nerve soon divides, contain bundles of fibres connected with both roots. It had long been observed that, in cases of palsy, sometimes the power of voluntary movement, sometimes the sense of touch was destroyed, and this, upon examination after death, was found to have been caused by a lesion of some part of the brain; at other times the same effect was produced by injury or disease of different parts of the spinal cord. About the beginning of this century this circumstance began to give rise to speculations on the possibility that the separate roots of the nerves might have separate functions, and that the fibres of each root which, though crossing and intermingling in their common sheath, are yet kept perfectly separate by the fine membrane or

* See Quain and Wilson's Anatomy of the Nerves, p. 35.

nerve lemma that invests them,—might be the means of carrying to the brain the sensations received at the extremities, on the one hand, and conveying back its mandates on the other:—in short, that these roots were respectively sensitive and motor, consisting of fibres communicating with certain tracts of the spinal cord, which in their turn communicated with the brain, and thus that injury of any part of the sensitive tract would destroy sensation;—or in like manner impede the propagation of movement to the limbs, if the injury happened to occur in its path. Curiosity being thus awakened, numerous experiments were made, in order to ascertain the fact: and living animals were mutilated and tortured without mercy for the purpose of determining which function belonged to which root. It is extraordinary that even if humanity did not prevent this, common sense at least should not have interfered so far as to suggest that when the processes of the spine have been hacked open,—when pain and loss of blood have disordered all the functions of nature,—and when,—happily for the poor animal,—death is imminent,—no rational conclusion can be formed as to the normal functions of the parts.* The controversy was long

* "Direct experiments on the anterior and posterior columns of the cord are surrounded with difficulties which embarrass the experimenter and weaken the force of his inferences. The depth at which the cord is situate, in most vertebrate animals, its extreme excitability, the intimate connection of its various columns with each other, so that one can scarcely be irritated without the participation of the others, the proximity of the roots of the nerves to each other . . . . sufficiently explain the discrepancies which are apparent in the results of the various experiments which have been published.—'If the anterior fasciculi of the cord,' observes Dr. Nasse, 'possess sensibility but only in a slight degree, the mere opening of the vertebral canal, and laying bare the cord, must cause such a degree of pain as would

and hot; and many opinions were broached as to the functions of the anterior and posterior roots of the spinal nerves which subsequent and calmer investigation has greatly modified. The common sense view too has gained ground, and it is acknowledged that a careful register of the phenomena of disease, followed by a post-mortem examination, is generally more to be depended on than the experiments, so revolting to humanity, which were at first resorted to; but from which, nevertheless, different therorists drew different results, each in favor of his own especial view of the case.

14. Whilst the controversy was yet raging with a fierceness hardly befitting a scientific question, Dr. Marshall Hall suddenly stepped in,* and gave a new character to the inquiry. He proved that there were many actions which appear to be voluntary which nevertheless take place during a state of utter insensibility,† or even, in some animals, as in

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weaken or destroy the manifestation,' &c." *Todd and Bowman's Phys.*, vol. i. p. 317.

Alas! that this should have been only a late thought! too late to prevent the infliction of tortures which the mind shrinks from contemplating, and which I will not pain my readers by detailing.

* I give the name of this gentleman because he was the most active in drawing attention to phenomena, which, though they had been noticed by some others, had not been sufficiently considered.

† The *cerebral* system of nerves conveys impressions from every part of the body to the *brain*, and the individual then *feels* them as *sensations*, and by the fibres of the same system, which pass from the brain to the muscles, the *will* acts upon them in producing voluntary motion. Now the brain is not in constant action, even in a healthy person; it requires rest: and during profound sleep it is in a state of complete torpor. Yet we still see those movements continuing which are essential to the maintenance of life,—the breathing goes on uninterruptedly,—liquid poured into the mouth is swallowed,—and the position is

the turtle, for instance, after decapitation: actions which continued to be performed for some time whilst the spinal cord remained intact, but ceased instantly on its removal. It was farther shown, that in the case of a monstrous birth, where the brain was wholly wanting, the infant, during some hours sucked and performed the other functions of complete animal life; and that in palsy, limbs which were insensible to the commands of the will, had yet their own proper movement. Hence it was very rationally inferred, that the spinal apparatus is sufficiently independent of the brain, to be capable of action without its aid, and that by its intervention many of the actions requisite to the preservation of life can be, and actually, in many instances, are performed: thus proving that *besides the unconscious vegetative life of the sympathetic system, there is an unconscious animal life, whose centre is to be found in the spinal cord.* For these functions, which he distinguished as *reflex*, Dr. Marshall Hall supposed a peculiar set of fibres to be appropriated, which he termed *excito-motory.* He considered that "the various muscles and sentient surfaces of the body are connected with the brain by nerve fibres which pass from one to the other. Those

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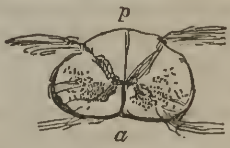
changed when the body would be injured by remaining in it. The same is the case in apoplexy, in which the actions of the brain are suspended by pressure upon it: and the same will take place in an animal from which the cerebrum is removed, or in which its functions are completely suspended by a severe blow on the head. If the edge of the eyelid be touched with a straw, the lid immediately closes: if a candle be brought near the eye the pupil contracts;—if liquid be poured into the mouth it is swallowed:—if the foot be pinched, or burnt with a lighted taper, it is withdrawn, and if this experiment be made upon a frog, the animal will hop away, as if to escape from the source of irritation. *Carpenter's Animal Physiology*, p. 356.

fibres destined for, or proceeding from the trunk to the brain, pass along the spinal cord, so that that organ is in great part no more than a bundle of nerve fibres going to and from the brain. These fibres are especially for sensation and voluntary motion. But in addition to these, there is another class of fibres proper to the spinal cord, and to its intercranial continuation which form a connection with the gray matter of the cord (15). Of these fibres some are afferent or incident, others efferent or reflex, and these two kinds have an immediate but unknown relation to each other, so that each afferent nerve has its proper efferent one, the former being *excitor*, the latter *motor*.—These fibres are quite independent of those of sensation and volition, and although bound up with sensitive and motor fibres, they are not affected by them, and they maintain their separate course in the nerves as well as the centres."* But this theory, however ingenious, is still but a theory; unsupported as yet by any anatomical proof, though the phenomena on which it is founded are established facts: it therefore awaits the confirmation, which perhaps we are never destined to attain, of a more accurate anatomical knowledge of parts so delicate in their structure, that they have hitherto in great measure baffled the inquirer. Before going further, however, it may be well to give what *is* known respecting the nature of the organ which plays so important a part in the animal economy.

15. "The spinal cord is somewhat cylindrical in shape, slightly flattened on the anterior and posterior surfaces," and is considerably thickened in those parts where the nerves supplying the limbs are

* Todd and Bowman's Phys., vol. i. p. 323.

given off or received. It is divided down the middle "by an anterior and posterior fissure into two equal and symmetrical portions, of which one may be called the *right*, the other the *left* spinal cord. A transverse bilaminate partition, extending through the entire length of the cord, separates these fissures from each other, and serves to unite the lateral portions. This partition is composed of a vesicular or gray, and a white or fibrous lamina or *commissure*, the gray being situated posteriorly.—On further examination of a transverse section of the cord we observe that the interior of each half of it is occupied by vesicular matter, disposed in somewhat of a crescentic form, thus:



The concavity of this crescent is directed outwards, its anterior extremity or horn is thick; but the gray matter is prolonged backwards in the form of a narrow horn, which reaches quite to the surface of the cord. The prolongation of the posterior horn of each gray crescent to the surface, divides each half of the cord into two portions. All that is anterior to the posterior horn is called the antero-lateral column, and this comprehends the white matter forming the sides and front of that half of the cord. The posterior column is situated behind the posterior horn of gray matter. The antero-lateral columns are united across the middle line by the anterior or white commissure;—the gray crescent by the pos-

terior or gray commissure, while the posterior columns are not connected, except when the posterior fissure is imperfect or deficient. The roots of the spinal nerves emerge from the cord on each side along two lines; the posterior line corresponds to the margin of the posterior horn of gray matter; the anterior one is placed about midway between it and the anterior fissure. The roots of the nerves penetrate the substance of the cord, and are chiefly, if not entirely, connected with the antero-lateral column. So far as our present knowledge of the minute anatomy of the spinal cord extends, it is favorable to the supposition that the spinal nerves derive their origin, at least partly, from the gray matter. The longitudinal fibres of the cord may consist in part of fibres continuous with those of the brain or cerebellum, and in part, of commissural fibres, serving to unite various segments of the cord with each other, or to connect some part or parts of the encephalon with them. These fibres which may be regarded as strictly spinal, are probably oblique in their course, forming their connection with gray matter at a point higher up in the cord than that at which they emerge from its surface, and may readily be confounded with the longitudinal fibres when their course is long. Other oblique or transverse fibres probably do not emerge from the cord, but connect the segments of opposite sides, forming a transverse commissure. So that four classes of fibres, each different in function, may be considered to exist in the cord. 1. *Spinal fibres* oblique or transverse, which propagate nervous power to or from the segments of the cord itself. 2. *Encephalic fibres;* longitudinal; the paths of volition and sensation, which connect the spinal cord with the various segments of the encephalon. 3. *Longitu-*

dinal commissural fibres. 4. *Transverse commissural fibres.*

16. Whilst the functions which, till a better term is found, we must term *reflex* (14), were as yet either unknown, or considered merely as isolated and strange phenomena; the controversy was warm as to the respective offices of the posterior and anterior columns of the cord, as well as of the two roots of the nerves: but nothing would now be gained by going over ground, much of which has been abandoned, and I prefer quoting the following very rational theory, which will give a notion of the question as it at present stands. "We are much disposed to think," say the authors of "the Physiological Anatomy of Man," "that the antero-lateral columns are the centres of the main actions of the cord. Both roots of the nerves are connected with these columns, and therefore fibres of sensation and motion must be found in them. These columns are always proportionate to the nerves which arise from them; they enlarge when the nerves are large, and contract when the nerves diminish in size. The posterior columns, on the other hand, are of uniform dimension throughout nearly the entire length of the cord, although the posterior roots of the nerves exhibit considerable difference in point of size in different regions. We venture to suggest, that the posterior columns may have a function different from any hitherto assigned to them. They may be in part commissural between the different segments of the cord, and in part subservient to the function of the cerebellum (17), in regulating and co-ordinating the movements necessary for perfect locomotion. The analogy of the brain, in which the various segments are connected by longitudinal commissures, suggest the probable existence of fibres similar in

office for the spinal cord. If we admit such fibres to be necessary to insure harmony of action between the several segments of the encephalon, there are as good grounds for supposing their existence in the cord, which in reality may be regarded as *consisting of a number of ganglia, each a center of innervation to its proper segment of the body*, and therefore requiring some special connecting fibres to secure consentaneous action with the rest. The attribute of locomotive power rests upon the connection of the posterior columns with the cerebellum, and the probable influence of that organ over locomotion. If the cerebellum be the regulator of locomotive actions, it seems reasonable to suppose that those columns of the cord which mainly pass into it should enjoy a similar function; that, as they are the principal medium through which the cerebellum is brought into connection with the cord, it must be through their constituent fibres that the cerebellum exerts its influence on the nerves of the lower extremities, and of other parts concerned in the locomotive function.—We think that the phenomena of disease may be referred to in support of our view. In many cases, where the principal symptom has been a gradually increasing difficulty of walking, the posterior columns have been the seat of disease. In a remarkable case related by Dr. Webster, there was complete paralysis of motion in the lower extremities, but sensibility remained;* yet there was com-

* Med. Chir. Trans., vol. xxvi. It had been maintained by Sir C. Bell in the first instance, that the posterior columns of the cord were the channels of *sensation*, as the cerebellum, in his opinion, was the seat of it; for the intimate connection of the two tend to make it necessary that their functions should be the same. The experiments of Flourens and Bouillaud disproved his views as to the functions of the cerebellum: it was then to

plete destruction of the posterior columns in the lower part of the cervical region. Similar cases have been put on record by Mr. Stanley, and by Dr. W. Budd. Dr. Nasse of Bonn, refers to several cases of the same kind, observed by himself or others.* We have ourselves seen two cases in which the prominent symptom was great impairment of the motor power, without injury to the sensitive; yet the seat of organic lesion in both was in the posterior column of the cord. Such a case as that of Dr. Webster's, appears to us to be conclusive...that sensation may be enjoyed in the inferior extremities *independently of the posterior columns*."—"Nevertheless we are not aware of any well-observed case, in which the motor power persisted after extensive lesion of the antero-lateral columns; on the contrary, we believe it may be laid down as the general rule, that lesion of those columns always impairs both the motor and the sensitive functions to an extent proportionate to the amount of morbid structure. Pathological observations, then, appear to warrant the conclusion, that the antero-lateral columns are compound in function, both sensitive and motor; but they do not justify us in attributing sensitive power to the posterior columns. The hypothesis, then, which we are most disposed to adopt, is the following:—That the *antero-lateral columns of the spinal cord with the gray matter*, are, in connection with the brain, the recipients of sensitive impressions, and volitional impulses, and that they are the centres of the independent or phy-

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be expected that sooner or later it would be found that the functions of the posterior cord were of the same nature as those of the organ with which it is connected so closely.

* Untersuchungen zur Physiologie und Pathologie. Bonn, 1835–36.

sical nervous actions of the cord: and that the *posterior columns* propagate the influence of that part of the encephalon, which combines with the nerves of volition to regulate the locomotive powers, and serve as commissures in harmonizing the actions of the several segments* of the cord."†

17. I have now briefly described the machinery of unconscious life:—first, we have the Sympathetic System (7), carrying on the functions of nutrition and secretion; the maintainer of vegetative life:—secondly, we have the Spinal Cord, and its dependent nerves, by which involuntary movements are effected, and to whose agency many of the actions termed instinctive may probably be referred; and thus far man and the animal creation stand on an equal footing, or rather the animal has the advantage; the spinal system of unconscious life being more complete, and less disturbed by other influences, than in man. We have next to consider that organ, or rather collection of organs which he possesses in an unrivaled degree of perfection, and by means of which all those complex mental operations are performed, which distinguish the human race from all the other inhabitants of the earth. The encephalon, or parts within the skull, may be distinguished into four chief divisions, i. e., 1. The *Medulla oblongata.*—2. The *cerebrum.* 3. *The cerebellum.* 4. *The mesocephale.** The following description of the position and connection of

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* By a segment of the cord, must be understood the part from which one pair of spinal nerves proceeds. To each pair of nerves a ganglion or nervous centre is attached, on the posterior root: it is possible, therefore, that these ganglia may have a larger share than has yet been attributed to them, in the independent segmentary action here alluded to.

† Todd and Bowman's Phys., vol. i. pp. 319–321.

‡ From μεσος, *middle*, and κεφαλὴ, *head.*

the parts taken from the report made to the Royal Academy of Sciences at Paris, in 1822, by a committee appointed to consider the experiments of M. Flourens, may give some notion of the encephalon generally.

"It is at present known, that the *medulla oblongata* is the superior part of the spinal cord, contained in the cranium, which also gives many pairs of nerves; that the fibres of communication between its two fasciculi (the pyramidal bodies) interlace with one another, so that those on the right go to the left side, and reciprocally; that these fasciculi, after having been enlarged, in the mammiferæ by a mass of gray matter, which forms the prominence known by the name of *pons Varolii*, separate themselves and are called the *crura cerebri*, continuing to send off nerves. They are again enlarged by a new mass of gray matter, to form the parts commonly called *thalami optici*, and a third time to form those called *corpora striata;* and from the whole external edge of these last swellings arises a lamina more or less thick, more or less convoluted externally according to the species, covered entirely on the outer surface with gray matter, forming what is called the *hemisphere.* This lamina, after having bent back upon itself in the middle of the convolutions, unites on the opposite side by one or more commissures or fasciculi of transverse fibres, the largest of which, existing only in the mammiferous tribes, takes the name of *corpus callosum*. It is also known that on the crura cerebri, behind the *thalamus opticus*, are one or two pairs of swellings of different magnitudes, known, when there are two pairs, as in the mammiferous tribes, by the name of *quadrigeminal tubercles*, from the first of which the optic nerves appear to arise; that the olfactory nerve is the only one which evidently does not arise from the spinal cord or its pillars; that the

cerebellum as a single mass, white internally and cineritious externally like the hemispheres, but often more divided by external folds, is placed transversely, behind the quadrigeminal tubercles, and over the medulla oblongata, to which it is united by transverse fibres, which go by the name of *crura cerebelli*, and which are inserted into the cerebellum by the side of the pons Varolii."*

In order to make this description clearer, I shall here refer to a plate,† showing a longitudinal section

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* Solly on the Human Brain, p. 299.

† References to the plate, which is reduced from Quain's Anatomy of the Nerves and Brain, Pl. ix.

A. The internal convolutions of the right cerebral hemisphere.

B. The corpus callosum.

C. The anterior extremity of the corpus callosum turning downwards towards the base of the brain.

D. The posterior border of the corpus callosum becoming continuous with

E. The fornix.

F. The right crus of the fornix descending to

G. The corpus mammillare.

H. The band of white fibres passing from the corpus mammillare into the thalamus opticus.

I. The septum lucidum.

K. The crus cerebri of the right side.

L. The divided edge of the velum interpositum.

M. Section of the pons Varolii through which the ascending fibres of N. the corpus pyramidale are seen separated by gray matter, as they pass onwards to the crus cerebri.

O. The interior commissure of the third ventricle.

P. The middle commissure (commissura mollis).

Q. The posterior commissure.

R. The right thalamus opticus immediately beyond which and somewhat anteriorly lies the corpus striatum.

T. The pineal gland.

U. The corpora quadrigemina or optic tubercles.

X. The processus é cerebello ad testes.

Z. Section of the cerebellum, showing the arrangement of the white and gray matter called arbor vitæ.

1. Olfactory nerve.
2. Optic nerve of the right side.
3. Third nerve (motorius oculi).

of the cerebrum and cerebellum made perpendicularly between the hemispheres.

As some fibres pass between the medulla oblongata and the cerebrum, and others between it and the cerebellum, both are thus brought into communication with the spinal cord, between which and the above-named parts the medulla oblongata is placed. The mesocephale is the part immediately above the medulla oblongata, the pons Varolii forming its lower, the quadrigeminal bodies its upper surface. It "contains fibres passing between all the rest of the encephalon, as well as some connecting opposite sides," and "may be compared to a railway terminus, at which several lines meet, and pass each other."*

18. "The whole brain of an adult man (a European) varies between 3 lbs. 2 oz. and 4 lbs. 6 oz. (troy) in weight. The higher grades of intellect being generally accompanied by a proportionate size of brain. Thus the brain of the celebrated Cuvier weighed 4 lbs. 11 oz. 4 dr. 30 gr. (troy), and that of the well-known surgeon Dupuytren 4 lbs. 10 oz. troy: while on the contrary the brain of an idiot 50 years old weighed only 1 lb. 8 oz. 4 dr., and that of another 40 years of age weighed but 1 lb. 11 oz. 4 dr." This great weight depends mainly on the cerebrum and cerebellum, the medulla oblongata and mesocephale forming not more than one-tenth of the whole.* The observation made above by Tiedemann as to the relative proportion borne by the brain to the intellect, is farther confirmed by the fact, that animals of a much larger size than man have a much less brain; thus the largest brain

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* Todd and Bowman's Physiol., vol. i. p. 260.

† Tiedemann on the Brain of the Negro. Phil. Trans., 1836.

of a horse weighs about 1 lb. 7 oz.—the elephant and whale, indeed, have a larger absolute weight of brain; but when considered with reference to the size of the body, it will be found that the proportion of brain is trifling as compared with that of man—an elephant has a brain of about 8 lbs., and "Rudolphi found the brain of a whale 75 feet long (*Balæna mysticetus*), to weigh 5 lbs. $10\frac{1}{4}$ oz.:"* an enormous disproportion between bulk of body and weight of brain.

19. It has already been noticed that though the entire encephalon acts as one great nervous center, it must nevertheless be considered as an aggregate of various gangliform masses of vesicular and fibrous matter, united together by their respective commissures or connecting bands. Of these masses, the most important are the cerebral hemispheres, which occupy the whole upper part of the skull. A deep fissure, extending from front to back, separates these two bodies down to the great commissure or *corpus callosum*, which unites them through their whole length; and the whole surface, as well the sides of the fissure as the upper part, is deeply corrugated, so as to bear somewhat the appearance of a pocket handkerchief closely crumpled in the hand. "In man the convolutions of the right and left hemispheres do not present a perfect symmetry; and it is not a little remarkable, that in general the lower the development of a brain the more exact will be the symmetry of its convolutions. Thus the brains of all inferior mammalia, even of those which make the nearest approach to man, are exactly symmetrical. The imperfectly developed brain of the child exhibits a similar symmetry; and that of the inferior

* Todd and Bowman's Phys., vol. i. p. 261.

races of mankind, in whom the neglect of mental culture, and habits approaching to those of the brute, are opposed to the growth of the brain, also present a symmetrical disposition of the convolutions."* Over the whole surface, and extending into the deep sulci of these convolutions, is spread a coating of gray vesicular matter, and as in the inferior animals the sulci are fewer, and of course the vesicular matter less abundant, it would seem that the object of these convolutions is, to pack the largest possible quantity of this important substance into the smallest possible space. The interior part consists of *white fibrous substance*, which is generally supposed to act as a conductor of the nervous energy generated in the *vesicular*. Behind and below these, so as to be connected by their overlapping lobes, we find the cerebellum or little brain. It "consists of a central and two lateral portions: the former also called the *median lobe*, is the primary part; it is the only part of the organ which exists in fishes and in reptiles; the lateral portions or hemispheres are additions to this, and denote an advance in development. It is in birds that these are first found; they are most highly developed in mammals, and attain their maximum in man."†

20. Having now given a general description of the organs which carry on the functions of life and intelligence, it remains to give a somewhat more detailed account of their machinery, and to prove from facts that such is really their office: and here we must enter into the melancholy details of disease and suffering. For as long as all the organs of our bodies continue to execute their functions duly, it is

* Todd and Bowman's Phys., vol. i. p. 283.
† Ibid., vol. i. p. 269.

difficult to say where the power is generated in that nicely adjusted machine. It is not till we see unwonted effects produced on the particular nerves by disease or violent injury, that we can distinguish their use. It is to the reports of the hospital, therefore, that we must refer for proofs of the different functions of the nervous fibres, and the influence of the brain over them: thus it may be noticed that in palsy, which results from an injury within the skull, the limbs of one side, or of the whole body, according as the injury is more or less extensive, are deprived sometimes of motion, retaining sensation; sometimes of sensation, retaining motion*—that the division of one nervous trunk issuing from the brain will impede digestion; of another, will no less disorder respiration—that by a tumor in one part of the cavity of the skull, the moving power of one side of the face will be destroyed, so that the odd spectacle may actually be seen of a man laughing with only one side of his mouth; in another, the sensation on one side of the face will be so lost that the eye becomes insensible to the presence of offending substances, so that inflammation ensues from an unfelt injury, though at the same time the other eye retains all its sensitiveness.†

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* See Solly on the Human Brain, Part viii.

† The following cases given by Sir Charles, then Mr. Bell, in a paper communicated to the Royal Society, and published in the Phil. Trans. for 1829, are so curious, and at the same time so conclusive, that I give them at length.

"By experiments on the nerves of the face three things were proved. 1st. That the sensibility of the head and face depends on the fifth pair of nerves. 2dly. That the muscular branches of the fifth were for mastication. 3dly. That the *portio dura* of the seventh controlled the motions of the features, performing all those motions, voluntary or involuntary, which are necessarily connected with respiration; such as breathing, sucking, swallow-

21. As a proof that sensation travels from the extremities of the body along the nerves to the brain,

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ing, and speaking, with all the varieties of expression. The occurrences which I have witnessed are,

"1. A man shot with a pistol ball, which entered the ear, and tore across the portio dura at its root. All *motion* on the same side of the face from that time ceased, but he continued in possession of the *sensibility* of the integuments on that side of the face.

"2. A man wounded by the horn of an ox. The point of the horn entered under the angle of the jaw, and came out before the ear, tearing across the portio dura. The forehead of the corresponding side is without motion, the eyelids remain open, the nostril has no motion in breathing, and the mouth is drawn to the opposite side. The muscles of the face, by long disuse are degenerated, and the integuments on the wounded side are become like a membrane stretched over the skull. In this man the sensibility of the face is perfect. The same nerve,—the portio dura,—has been divided in the extirpation of a tumor from before the ear, and the immediate effect has been a horrible distortion of the face by the prevalence of the muscles of the opposite side, but without the loss of sensibility.

"As to the fifth nerve the facts are equally impressive. By a small sacculated tumor affecting the roots of this nerve, the sensibility was destroyed in all the parts supplied by its widely extended branches; that is, in all the side of the head and face, and the side of the tongue, whilst the motion of the face remained. By the drawing of a tooth from the lower jaw, the nerve which comes out upon the chin to supply one-half of the lip was injured, and exactly the half of the lip was rendered insensible. When the patient put his mouth to a tumbler he thought they had given him a broken glass. A gentleman falling, a sharp point entered his cheek and divided the infra-orbitary nerve (a branch of the fifth); the effect was, loss of sensation without loss of motion in that half of the upper lip to which the nerve is distributed.

The following is from a previous paper by the same writer. "To understand the inference from the following short narrative, it is necessary to remember that the nerve in question (the fifth) not only goes through the orbit (of the eye), supplying the parts contained in it, but also extends its branches to the angle of the eye, eyelids, and forehead. . . . . A few days after the discharge from the ear had ceased, the eye became entirely insensible to the touch. This loss of feeling extended to the lining of the eyelids, to the skin covering them, and to the skin of

we may mention the fact that when a part containing the termination of any nerve is amputated, the pain felt in the extremities of the now-shortened fibres of that nerve is referred by the patient to the member which in their perfect state they supplied. Thus when a limb, for instance, has been cut off, the patient not unfrequently complains of pain in the fingers which he no longer possesses.* It is not in fact till experience has taught us that a distinct sensation belongs to each point of the body, that we refer to that part as the seat of the feeling. "Under the name of common or general sensibility, may be included a variety of internal sensations, ministering for the most part to the organic functions, and to the conservation of the body. Most parts of the frame have their several feelings of comfort and pleasure, of discomfort and pain. In many of the more deeply seated organs, no strong sensation is ever excited, except in the form of pain, as a warning of an unnatural condition;" nay, it has been observed in the case of injuries which have exposed some of these deeply seated viscera, that the sense of touch appeared to be absent. It is remarkable that the sympathetic system of nerves sends one fibre of its own from each ganglion into the spinal system; and this it would seem, is the messenger by which notice is given at the mental center, of the unnatural condition into which any of the organs supplied by the ganglionic nerves may have fallen,

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the cheek and forehead, for about an inch surrounding the eye, but it did not go beyond the middle line of the face. When she (the patient) told me her eye was *dead*, (as she expressed it,) to be certain I drew my finger over its surface, and so far was this from giving her pain, that she assured me she could not feel that I was touching it at all."—*Phil. Trans.*, 1823, p. 291.

* Muller, p. 746.

in order that, when this is the case, a remedy may be applied, so as to prevent the danger to life which would be consequent on its continuance.

22. Besides this general sensibility, whose proper organs are still a matter of uncertainty, there are five especial forms of sensation, each provided with its separate apparatus. It is hardly necessary to say that these are *touch*, *taste*, *smell*, *hearing*, *sight*. The nerves of touch are distributed over the whole surface of the skin, though some parts, such as the palm of the hand, and the sole of the foot, receive a larger portion of these fibrils than are found elsewhere. This sense "exists only in those regions of this great system which are exposed to the contact of foreign bodies, and where it is essential to the comfort or preservation of the animal that the presence and qualities of external objects should be perceived. Its nerves, unlike those of the other especial senses, which have their origin in the brain, are derived from the cerebro-spinal system, and intermingle, as they pass out, with those of motion. The extremities of these nerve fibrils pass through the true skin or *cutis* into small papillæ which project into, and are further defended by the cuticle, or scarf skin, which covers them. The furrows which may be observed in the skin are caused by rows of these papillæ which raise the cuticle, and leave a groove where it sinks into the hollows between them." These papillæ are of an average length, in man,—of $\frac{1}{100}$ of an inch: at their base when they spring from the cutis they measure about $\frac{1}{250}$ of an inch in diameter, and they taper off to a slightly rounded point." Within them "a fibrous structure is apparent," and by the help of solution of potass "filaments of extreme delicacy are discoverable. Injections of the blood-vessels demonstrate the exist-

ence of a small arterial twig advancing up the interior of the papilla and subdividing into two or more *capillary vessels:* these, after forming small loops, re-unite either at the base of the papilla, or in the subjacent texture, into small veins which empty their blood into the venous plexus of the cutis. The vascularity of the integument is therefore in general terms proportioned to its perfection as an organ of touch."*

23. It has already been seen that it is difficult to separate the nerves of touch from those of general sensation, even in imagination, and yet there are not a few phenomena of sensation quite independent of this especial sense: pain especially; which continues to be felt after the sense of touch is lost by palsy, and which affects parts to which these nerves are not distributed. The only set of nerves which are invariably to be found where pain is felt, are those of the sympathetic system; for these belong especially to the viscera, and send out twigs which cling to all the arteries: thus it is impossible to wound any part of the body without injuring some fibre of this system: and as it is to it that the functions of vegetative life are especially entrusted, it is perhaps allowable to conjecture, in default of actual proof, that it is to it also that the business of giving notice of any derangement in or impediment to these functions is confided, and that the general sensation which is independent of touch, may be referred to these nerves.

24. The structure above described is in great measure that of all the other nerves of especial sense, which are limited to their respective organs, i. e., the nostrils, mouth, eyes, and ears. Each of

* Todd and Bowman's Physiol., vol. i. pp. 404, 410, 411.

these organs has its own nerve assigned to it, which receives and transmits the impressions belonging to that particular sense and no other. Every surgeon knows that the needle of the operator for cataract produces only the perception of a flash of light when it touches the fibrils of the optic nerve, and that pain and sensibility to touch remain after the optic nerve itself has perished. The like may be observed of all the other nerves of especial sense. So far therefore is clear enough; but the *mode* of conveying impressions is more mysterious, and it is not improbable that we may never arrive at more than a conjectural explanation of it. The optic nerve, when observed with a powerful magnifier, appears to be formed of innumerable minute fibrils which pierce through the delicate membrane at the back of the eyeball, called the retina, and show themselves on its surface, for the most part in the form of small globules or papillæ easily detached, and which appear to close the ends of the hollow fibres. The

PORTION OF THE OPTIC NERVE MAGNIFIED.

auditory nerve has something of the same appearance, though the fibres are less minute than those of the optic nerve, and the points which show themselves on the membrane they penetrate, differ slightly from these in their form. It seems probable that

both these nerves are destined to receive impressions from different undulatory movements, the one conveying the sensation of light, the other of sound; and though it would be presumptuous to say that the modus operandi can be certainly or distinctly stated, yet a very simple illustration may perhaps give some notion of it to those who have not time to pursue the study further. When a hollow tube is filled with liquid, the slightest pressure at one end is instantly perceived at the other. If, then, as modern observers assert, the nerves be hollow fibres filled with a half fluid substance which may be seen issuing from them if divided, then it is easy to comprehend that the impression made at one end of the fibril may be conveyed through every fibril connected with it down to the extremest point of the motor nerves. What the difference of structure is, which makes this impression in the one instance convey colors, in another sounds, and, when propagated further, produces that irritation of the muscles which causes movement, has as yet eluded observation; but it is evident from the result, that some decided difference must exist. Time was, indeed, when "the nerves of the senses were looked upon as mere passive conductors, through which the impressions made by the properties of bodies were supposed to be transmitted unchanged to the sensorium. More recently, physiologists have begun to analyze these opinions. If the nerves are mere passive conductors of the impressions of light, sonorous vibrations, and colors, how does it happen that the nerve which perceives is sensible to this kind of impression only, and to no others, while by another nerve odors are not perceived; that the nerve which is sensible to the matter of light or the luminous oscillations, is insensible to the vibrations of sonorous bodies; that the

auditory nerve is not sensible to light, nor the nerve of taste to odors; while, to the common sensitive nerve, the vibrations of bodies gives the sensation, not of sound, but merely of tremors? These considerations have induced physiologists to ascribe to the individual nerves of the senses a special sensibility to certain impressions, by which they are supposed to be rendered conductors of certain qualities of bodies, and not of others.

"This last theory, of which ten or twenty years since no one doubted the correctness, on being subjected to a comparison with facts, was found unsatisfactory. For the same stimulus, for example, electricity, may act simultaneously on all the organs of sense,—all are sensible to its action; but the nerve of each sense is affected in a different way, becomes the seat of a different sensation; in one, the sensation of light is produced; in another, that of sound; in a third, taste; while in a fourth, pain and the sensation of a shock are felt. Mechanical irritation excites in one nerve a luminous spectrum; in another a humming sound; in a third, pain. An increase of the stimulus of the blood causes in one organ spontaneous sensations of light; in another, sound; in a third, itching, pain, &c." It is evident, therefore, "that the nerves of the senses are not mere passive conductors, but that each peculiar nerve of sense has special powers or qualities which the exciting causes merely render manifest."*

25. It has been noticed above, that the immediate vital functions are carried on by the sympathetic system. In like manner, the nerves of special sense seem to be connected with the instinctive emotions.

* Müller's Elements of Physiology, translated from the German by William Baly, M. D. Sec. iv. chap. 1.

Any accurate observer of animals may soon convince himself of this. Without insisting on the complete exactness of the illustration just given of the mode in which these nerves convey the impressions they receive, it may at least afford a point of view from whence to contemplate the operations of instinct. An organ made, not only to receive, but to propagate a particular sensation, receives it; the shock is sent in a moment through the less complete, or, as in the case of the savage, the less exercised brain to the motor nerves, and movement ensues as a necessary consequence. According to Mayo, there is no evidence that animals exert any volition beyond this necessary contraction of the muscles consequent on received sensation. If so, the actions which we choose to call ferocious, crafty, cowardly, &c., among the brute creation, are wholly undeserving of this blame. They are feelings inseparable from perceptions conveyed by the organs of smell, sight, and hearing, and necessary to the sustenance and the safety of the creatures which possess them.

26. But the actions which the emotions consequent on these perceptions instigate, are, in many instances, exactly such as intelligence would suggest. The young calf seeks the udder as soon as it is born, but it is evident that he is merely led thither by the sense of smell; for instead of at once reaching the spot, he pushes his nose awkwardly hither and thither, and it is only when his mouth is touched, and the nerves of another sense thus excited, that he begins to suck. The movements of a lamb following its mother, of a dog hunting its prey, of a bird building its nest, result in the same way from impression on the nerves of sense.

But although the animal actions we have mentioned, when their nature is considered, seem to be as

intelligent as if human reason had instigated them, it may easily be proved that the sagacity from which they proceed is extremely limited in its extent. For whenever any cause leads the animal to transgress those bounds, it is then seen at once how different reason is from instinct. Such is the case of a puppy when rubbing its nose on a brick floor to bury a bone: of a hen sitting on a stone instead of an egg; such likewise was the case with the beavers which Frederick Cuvier kept in a cage. These animals, on being supplied with materials, employed themselves in building that particular structure which, essential as it is to their existence when at large, and in their natural state, was then utterly without use or meaning.

27. The obvious conclusion from hence is, that, whatever faculty the instinctive impulse elicits, is incapable of advancing beyond a certain point in this class of creatures, and is unserviceable for any other act of intelligence. "Cette pensée qui se considère elle-même, cette intelligence qui se voit et qui s'étudie, cette connaissance qui se connait, forment évidemment un ordre de phénomènes déterminés d'une nature tranchée, et auxquels nul animal ne saurait atteindre. C'est lá, si l'on peut ainsi dire, le monde purement intellectual, et ce monde n'appartient qu' à l'homme. En un mot, les animaux sentent, connaissent, pensent; mais l'homme est le seul de tous les êtres créés à qui le pouvoir ait été donné de sentir qu'il sent, de connaître qu'il connait, et de penser qu'il pense."*

28. But though the animal intelligence, with whatever labor it may be cultivated, be unfit for

* Resumé analytique des Observation de Frédéric Cuvier sur l'Instinct et l'Intelligence des Animaux. Par P. Flourens, p. 55.

any speculative purpose, this defect is compensated for by its fitness for practical purposes without any previous exercise. The cause of this is the comparatively small compass of apparatus connecting sensation with action in the lower tribes; and as they are thus in great measure exempt from the painful apprehension of danger, and from perplexity at the time that it occurs, it is in their case decidedly beneficial. In man, the relations between the sensitive and motor fibres of the nerves issuing from his brain are liable to be confused with those of higher intelligence, in consequence of the more complicated functions of that organ. This structure of his nervous system exposes him to inconvenience and hazard, which other animals are exempt from. The dizziness produced by looking down a precipice is known to every one; were we to try to cross a chasm on a narrow plank, we should be very apt to lose our balance and fall, if unused to the situation; yet we should walk steadily along the same board placed on the floor. In this case it is evident that our real condition would not be changed; but that the danger would arise entirely from the difference in the perception received by the eye and communicated by it to the organs of intelligence. It may be observed that throughout the animal kingdom this timidity seems to increase with the degree of intelligence belonging to the creatures placed in such situations. Goats and ibexes stand at the edge of precipitous rocks, and gaze fearlessly on the depths beneath; but the carnivorous animals, which are more intelligent* than the ruminating tribes, show considerable alarm when exposed to this danger, though on other occasions they are more courageous.

* Flourens.

Cats, for example, though accustomed to climb, are frightened and unsteady when put on the bough of a tree at any considerable height, and there can be little doubt that the instability of the human frame, under the circumstances described, is augmented by the disturbed state of the reasoning faculties arising from foreseeing the probability that our alarm will increase. I am also inclined to think that where the disturbance in the functions of the motor fibres is not caused by fear, it arises from the want of some near and steady object, by looking at which we may adjust the body so as to poise it duly. A distant horizon with no intermediate near object, such as it is in looking from a precipice; or a rapid current, does not afford this, and we falter. And this possibly is one cause of reeling in drunkenness: the functions of the optic nerve are disturbed by the unwonted pressure of blood on the brain, and everything appears to be in motion: accordingly, having nothing steady before him, the drunkard reels. The narrowest ledge on the side of a precipice may be crossed safely, by looking steadily at the rock beside us, instead of at the chasm below.

29. Before quitting this part of the subject, it will be well again to observe, that the fibrils which converge from every part of the body, from the trunks of the nerves, never in any instance unite with each other. Thus every one carries its report from the part which receives the impression, distinctly and separately to the brain; and, as the white substance of that organ, in whatever form it appears, is also composed of minute fibres sustained and clothed by a most delicate membrane, so we have good reason to suppose that the sensation carried by the finest fibril from the remotest part of the body, is communicated to its own especial fibril in the brain, and

through it duly transmitted to the corresponding motor fibre.

30. But another circumstance is here to be observed.* The sum of all the fibrils in the nerves does not by any means amount to the volume of the brain even in the lower order of animals; still less in man, in whom, though the volume of the brain be proportionally greater, the nerves are less; thus there must be many fibres destined to some other purpose than that of mere conductors of sensation. But it is likewise remarked that they have a plexiform arrangement; and thus the simple fibril of sensation, though not mixing with any other, may nevertheless, by its intercrossing, communicate whatever shock it may receive through a different series of nerves, and so give rise to those varieties of action which sometimes excite our surprise when we see them in the brute creation, because they seem to partake of the nature of reason. But if the reasoning faculties be, as I shall presently show, the mere function of an organ, then, in proportion as that organ is developed, its properties will also be developed, and it is at the option of the will which directs them to make those properties available, or not, to other and higher purposes than those relating to mere animal life. I have already noticed that we have no proof of any will in the *animal* beyond the mechanical one resulting from a shock transmitted through the nervous circle. Of the will of *man*, as it belongs to a second class of functions, I shall speak by and by.

31. It has already been observed, that the brain consists of various portions, which may be con-

* On Fibres of Spinal Marrow and Sympathetic in Rana esculenta. Dr. A. W. Volkman, Brad. Med. Rev., vol. vii. p. 541.

sidered as separate ganglia, each probably having a different function, though hitherto but few of these functions have been ascertained. Of these gangliform masses the cerebral hemispheres take the first place in the importance of their office—the cerebellum probably takes the second, and next to these, perhaps we may reckon the corpora striata and optic thalami, for a lesion of either of these bodies is invariably attended with palsy of the limbs, so that they appear to play an important part among the animal functions. Both consist of gray vesicular matter. It has been attempted to decide with more certainty on the office of these bodies; and palsy of the lower extremities has been attributed to lesions of the one—of the upper, to the other;—but these conjectures have not as yet been sufficiently borne out by facts to warrant further notice. The functions of the corpora quadrigemina, or optic tubercles, are better defined, at least as far as the experiments made on pigeons by M. Flourens can be considered to apply to other species. In every case he found that injury to the optic tubercle on the one side, produced blindness of the eye on the opposite side; establishing thus a complete decussation of the fibres; and according to his report, the removal of these parts was attended with little or no pain. With regard to the office assigned to the other small ganglia and lesser commissures, no very clear account can be given, for their proximity to other parts renders it impossible that the injury should be confined to them alone: and thus symptoms become complicated, and puzzle and embarrass the observer.

32. The function of the cerebellum was long a matter of dispute, no less hot than that respecting those of the different columns of the spinal cord, and even now in following the opinion of any one

of the contending parties, I shall hardly escape altogether from animadversion. Sir Charles Bell and M. Foville, observing its connection with the posterior column of the spinal cord, considered it as the organ of sensation—this opinion, however, was subsequently abandoned by Sir Charles Bell, who then professed himself unable to assign any office to it. The subject was then taken up by M. M. Majendie, Bouillaud, and Flourens, especially the latter, and after a variety of experiments, always producing the same results both in his own hands and those of the physiologists who have since repeated them, it seems now to be allowed that the deductions drawn from them by M. Flourens are nearly conclusive, and that this body must be considered as the organ by which action is co-ordinated and harmonized in the animal frame; or, in other words, that it is the organ of voluntary action, as distinguished from the involuntary or reflex action of the spinal nerves. M. Flourens removed from different birds in turn the cerebral hemispheres and the cerebellum. On the ablation of the first, sight and hearing seemed to be lost, and the animal appeared without faculties; remaining as it were dormant, originating no movement, but if pushed, able then to use its limbs in the usual way; but when the cerebellum was removed the results were very different, and it may be well also to mention, that in neither one nor the other case did the wounds of these parts appear to give any pain.* "During the ablation of the first slices," (of the cerebellum), say the committee above referred

* "The hemispheres of the brain are insensible to pain from mechanical division or irritation: in wounds of the cranium in the human subject, pieces of the brain which had protruded, have been removed without the knowledge of the patient." Todd and Bowman's Physiol., vol. i. p. 368.

to (17), "only a little weakness and a want of harmony in the movements occur. At the removal of the middle slices an almost general agitation is the result. The animal, continuing to hear and to see, only executes abrupt and disorderly movements. Its faculties of flying, walking, standing up, &c., are lost by degrees. When the cerebellum is removed, the faculty of performing regulated movements has entirely disappeared. Placed on its back the creature could not get up; yet it saw the blow that threatened it, it heard noises, it endeavored to avoid danger, and made many efforts to do so without accomplishing its object. In brief, it retained the faculties of perception and of volition, but it had lost the power of making its muscles obey its will. It was with difficulty that the bird stood up, resting upon its wings and tail. Deprived of its cerebrum it was in a dormant state; deprived of its cerebellum it was in a state of apparent drunkenness." M. Bouillaud differs a little from M. Flourens, but not to any great extent. "Up to this time," says he, "experiments only warrant us in saying that the cerebellum is the central nervous organ which gives to vertebrated animals the faculty of preserving their equilibrium, and of exercising the various acts of locomotion. Besides, I think I have proved in another memoir, that the cerebellum co-ordinates certain movements, those of speech in particular, more marvelous than those of which we are here treating."—"If" he adds, "the cerebellum is only irritated, its functions are not destroyed, but are thrown into confusion, if I may so express it, for a certain time. It is in this state that we observe jumping, falling heels over head, whirling, and all the puzzling movements which are executed with such impetuosity that the eye cannot follow them. But this disorder, this

species of *alienation* of the locomotive movements, soon disappears when the irritation is not continued; so that the animal gradually regains its proper attitude and normal gait. It is not so when the cerebellum is totally disorganized or entirely removed; the animal is then forever deprived of the faculty of equilibration, of walking, and of flying, if a bird; all the efforts it makes are useless; they merely demonstrate that though unable to perform any combined motions, out of which station or locomotion results, it nevertheless retains the faculty of exercising partial movements."*

33. A curious case is on record, which confirms this view of the functions of the cerebellum as regards the human species. On the post-mortem examination of a girl, who died at near twelve years of age, it was found that "the cerebellum was entirely wanting, nothing being found in its place but a quantity of serous fluid contained in the membranes; —a pedunculated body, not larger than a pea, was attached to the corpora restiformia; all the rest seemed replaced by the serous sac; the pons Varolii was absent, as well as the cerebellum."—In this instance, it would seem that the malformation must have been in great measure congenital, for had it been caused by subsequent injury, the shock to the constitution generally would have been too great to allow of the prolongation of life, even to the age she attained. The degree of mental and bodily power enjoyed by this child, becomes therefore a question of no small interest. "The intellectual faculties," continues the writer,† "were obtuse, though not to

* Bouillaud, Recherches cliniques et experimentales tendant à refuter l'opinion de M'Gall sur les fonctions au cervelet."—Cited by Solly.

† Andral.

a remarkable degree; the answers slow and difficult; the whole countenance expressive of stupidity: in a word, the child, though not exactly idiotic, still showed a deviation of the mental powers. The motility was also modified; the power of motion was considerably weakened in the lower limbs, which did not possess their natural force and vigor; hence the child was unable to support itself with any firmness: it fell down frequently; the legs crossed each other during walking, and the gait was irregular and unsteady. At length the child was compelled to confine itself altogether to bed, and after some time was unable to stir, even when lying in a horizontal position;—to this were joined epileptiform convulsions, which continued for some time, and finally carried off the patient. The sensation of the integumental covering was not modified in any way whatever. There was no increase of sensibility in the commencement, no obtuseness or diminution of feeling, even when paralysis was most complete; the senses also remained intact. The child could see, hear, and taste in a perfect manner. The functions of nutrition, of circulation, and respiration were carried on without any notable disturbance." However, the child is mentioned as being weak and delicate in constitution.

34. The progress of development in the brain of infants affords a farther confirmation of the view taken by M. Flourens, of the functions of the cerebellum in co-ordinating the voluntary movements. "That this power is mental, i. e., dependent on a mental operation for its excitation and exercise," observe the authors of the Physiological Anatomy of Man, "is rendered probable from the experience of our own sensations, and from the fact that the perfection of it requires practice. The voluntary movements of a new-born infant, although perfectly

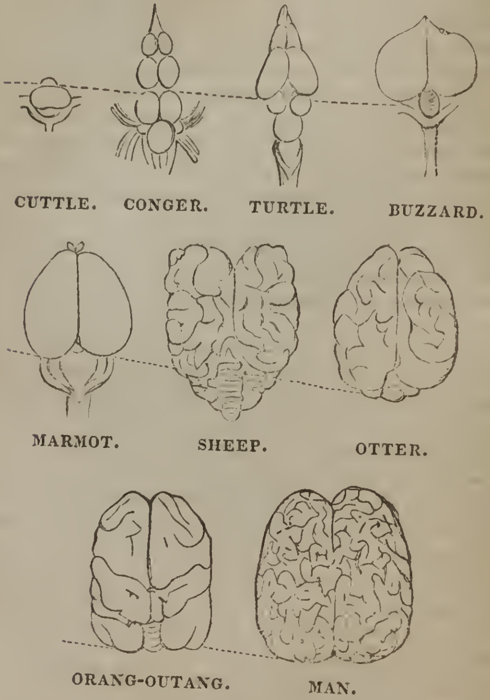
controllable by the will, are far from being co-ordinate; they are on the contrary remarkable for their vagueness and want of definition. Yet all the parts of the cerebro-spinal centre are well developed, except the cerebellum and the convolutions of the cerebrum. Now the power of co-ordination improves earlier and more rapidly than the intellectual faculties; and we find in accordance with Flourens' theory, that the cerebellum reaches its perfect development of form and structure at a much earlier period than the hemispheres of the cerebrum." From all this it seems clear that the cerebellum is requisite to the execution of all pre-arranged movements, and in proportion as the cerebrum increases in bulk and complexity, the cerebellum receives a similar augmentation, so that they would seem always to have a certain relation to each other. After demonstrating what are the functions of the cerebrum, I shall return to the mutual relation of the two.

35. The proof of the function of any organ must be of two kinds; first, it must be demonstrated that when the function is performed in its greatest perfection, the organ is proportionably developed: secondly, it must be shown that a lesion of this organ impairs the function which it is supposed to fulfill. Both kinds of proof may be given, that the functions of the cerebral hemispheres are those of intelligence. The following sketch shows the proportion which these bodies bear to the rest of the encephalon in different classes of animals: the part above the dotted line is that which answers to the cerebral hemispheres.

It is evident therefore as has been remarked* by

* Owen on Structure of the Brain in Marsupial Animals, Ph. Tran. 1834, p. 358—1837, p. 89.

physiologists, that the development of the hemispheres of the brain proceeds step by step with the development of intelligence through the successive classes of the animal kingdom till it arrives at perfection in man. "Who has not seen," says Dr. Fletcher,* "artificially educated horses, dogs, lions,



* Physiology, Part III. p. 89.

pigs, elephants, bears, monkeys, canary-birds, and even hens; but who has ever seen, or ever will see, an educated worm or oyster? The educability of animals, then, or in other words their intellect, is in proportion to the size and composition of their brains." Thus, of all animals, man, who has the largest and most complicated brain is the most improvable; he can judge, compare, discriminate, and remember all the impressions made on his senses with far more precision than any other of the mammalia. This was to be expected from the structure of his brain, which differs in many points from all others; but here a most important fact presents itself. With the development of the brain in the animal, proceeds also its intelligence; but the individuals of each class retain a close resemblance to their common type; the greatest difference that can be produced by education between the wild and the domesticated animal is so small as scarcely to be worth the notice; since it consists in little else than a sensation of fear impressed by the felt power of man: but when we look at the human race, so great is the difference between civilized and uncivilized man, that some physiologists have endeavored to find in the brain of the latter a resemblance to the quadrumana rather than to his more cultivated brethren. Yet there is no perceivable distinction in the cerebral organs of individuals constituting the most clearly defined varieties of the human race. Whether civilized or uncivilized, male or female,*

* "Although Aristotle has remarked that the female brain is absolutely smaller than the male, it is nevertheless not relatively smaller compared with the body: for the female body is in general lighter than that of the male. The female brain is for the most part even larger than the male, compared with the size of the body.

we find the same component parts, the same relative proportion of brain. Whence then the immense difference between the negro in his African wilds, and the European philosopher?

36. I think some of the points I have endeavored to establish will in great measure explain this. Every bodily fibre acquires strength by exercise: none need be told how much muscular power is acquired by a constant and moderate exertion: the practised eye will see, the practised ear hear, what these organs when unpractised distinguish with difficulty; it is not wonderful then, if the practised brain can also carry on its functions with greater facility and increased power. In savage life, where subsistence is hardly obtained, and where danger is always at a point that keeps the emotions which guard existence in constant exercise, men who have to struggle for their daily food, and defend themselves from their no less daily perils, require from the brain but a very small part of what it *can* accomplish: their greatest stretch of reasoning extends not beyond the connecting a bent twig, or a down-trodden leaf, with the steps of their prey or their enemy. In such instances, we

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" The different degree of susceptibility and sensibility of the nervous system seems to depend on the relative size of the brain as compared with that of the body. Children and young persons are more susceptible, irritable, and sensible than adults, and have a relatively larger brain. The degree of sensibility in animals is also in proportion to the size of the brain. Mammalia and birds have a larger brain and are more susceptible than amphibious animals.

" The brain of a negro boy 14 years old weighed, according to Sœmmering, 3 lbs. 6 oz. 6 dr. troy. The brain of another handsome tall negro about 20 years of age weighed 3 lbs. 9 oz. 4 dr. troy. Sir Astley Cooper gives the weight of the brain of a large negro 49 oz. The general weight of the brain of man is from 37 to 52 oz."—*Tiedemann on the Brain of the Negro*, Phil. Trans., 1836.

may easily conceive that the unexercised faculties become as powerless as the limb of an animal which from the moment of birth had been restrained from movement. A child who had grown up with a limb so disabled, would not be aware of its use unless he saw it exemplified in others, and even if he saw its use, he would still find that in his own case the effort to make it available would be perfectly vain.

37. Such I conceive to be the state of the brain which has never been called to exercise the higher faculties. The instinctive emotions are propagated through it with the almost delirious violence which characterizes the brute creation, because the fibres destined to carry on the higher reasoning functions have remained inert till they have become powerless, and man is thus assimilated to the lower tribes, not because the organ of thought is wanting, but because it has not been exercised. Christophe, the negro ruler of Haiti, was probably not removed above a generation or two from the African savage, yet his daughters were polished and accomplished women, fit to take their place in European society. A better proof could hardly be given of the improvability of all the races of men by education, even in *one* generation.

38. It now remains that I give the second part of my proof, and show that a lesion of the cerebral hemispheres impairs the functions they are supposed to fulfill, *i. e.*, that of intellectual perception. And here I must notice that a considerable analogy may be traced between the arrangement of the brain and that of the organs of special sense. Thus as we have two eyes, two ears, two nostrils: so we have also two hemispheres of the brain, and we may remark as a consequence of this, that a serious injury, amounting nearly to the removal of one hemisphere,

does not necessarily abolish the functions of thought, any more than the loss of one eye or the failure of one ear produces absolute blindness or deafness. I have heard an instance of a young boy who was dashed on the ground by a fall from his horse, with such violence as to shiver one side of his skull, and a large quantity of the brain, nearly amounting to the magnitude of one hemisphere, actually issued from the wound. When this youth had recovered, he was so far from manifesting any want of intellect, that he attained considerable proficiency in mathematics. This case runs parallel with that of persons who have gone on for a considerable time deriving their sight from one eye, and quite unconscious that they had not the use of the other. Such cases are to be met with frequently in medical books; and it appears from what has been observed with regard to animals, that "where a portion of the brain is removed, its place is supplied by new matter; but whether this becomes true cerebral substance," it is added by the writers already frequently quoted, "future researches with good microscopes must determine."

39. The actual removal of a portion of the cerebral hemispheres may take place, therefore, without ill consequence, unless inflammation should follow in consequence: but compression, which prevents the movement of the fibres, and consequently the transmission of impressions, produces total insensibility. "Sir A. Cooper used to relate in his lectures on surgery one of the most interesting and unique cases on record. A man was pressed on board one of his majesty's ships early in the late revolutionary war. While on board this vessel in the Mediterranean he received a fall from the yard arm, and when he was picked up he was found to be insensible.

The vessel soon after making Gibraltar, he was deposited in a hospital in that place, where he remained for some months, still insensible; and some time after he was brought from thence to a depôt for sailors at Deptford. While he was at Deptford, the surgeon, under whose care he was, was visited by Mr. Davy, who was then an apprentice at this hospital: the surgeon said to Mr. Davy, 'I have a case which I think you would like to see. It is a man who has been insensible for many months; he lies on his back with very few signs of life; he breathes, indeed, has a pulse, and some motion in his fingers; but in all other respects he is apparently deprived of all powers of mind, volition, or sensation.' Mr. Davy went to see the case, and on examining the patient found a slight depression on one part of the head. Being informed of the accident which had occasioned this depression, he recommended the man to be sent to St. Thomas's Hospital. He was placed under the care of Mr. Cline, and when he was first admitted into the hospital, I saw him lying on his back, breathing without any great difficulty, his pulse regular, his arms extended, and his fingers moving to and fro to the motion of his heart, so that you could count his pulse by this motion of his fingers. If he wanted food he had the power of moving his lips and tongue; and this action was the signal to his attendants for supplying this want. Mr. Cline on examining his head found an obvious depression; and thirteen months after the accident he was carried into the operating theatre, and there trephined. The depressed portion of the bone was elevated from the skull. While he was lying on the table motion of his fingers went on during the operation, but no sooner was the portion of bone raised than it ceased. The operation was performed

at one o'clock in the afternoon; and at four o'clock, as I was walking through the wards, I went up to the man's bedside and was surprised to see him sitting up in his bed. He had raised himself on his pillow. I asked him if he felt any pain, and he immediately put his hand to his head. This showed that volition and sensation were returning. In four days from that time the man was able to get out of bed, and began to converse; and in a few days more he was able to tell us where he came from. He recollected the circumstance of his having been pressed, and carried down to Plymouth or Falmouth; but from that moment up to the time the operation was performed (that is, for a period of thirteen months and some days), his mind had remained in a perfect state of oblivion. He had drunk, as it were, the cup of Lethe; he had suffered a complete death as far as regarded his mental and almost his bodily powers; but by removing a small portion of bone with the saw, he was at once restored to all the functions of his mind, and almost all the powers of his body."*

40. When death supervenes from furious mania, it is usually found on examination that the cortical substance is in a state of inflammation if not of gangrene. The following cases are selected from the records of the hospital of La Salpêtrière at Paris. "A woman of advanced age but strong constitution was brought to this hospital October 20, 1821, by order of the police. She was in a state of extreme and furious agitation; her eyes were brilliant, her exclamations violent: her delirium was upon all subjects, but there were no means of ascertaining what had been the cause or what the commencement of this

* Solly on the Human Brain, p. 334.

attack of furious mania. For six months it continued without the least interval of calm; but on March 13, 1822, this woman, so restless the evening before, was stretched on her bed without the power of rising: she was calm, her face pale and yellow, her eyes fixed and half open, her head bent to her left shoulder, her respiration stertorous, her pulse hard and quick. At night she had again a paroxysm of violence during which she struggled and fell out of bed. The next day the symptoms were still more serious, her whole left side was paralyzed; on the third day the stupor increased and in the night she died.

"The post-mortem examination presented the following appearances. The cranium itself was much injected with blood of a dark color: the meninges were healthy, but raised by a considerable quantity of serous fluid beneath: when the membrane was removed, the periphery of the organ was found much injected with blood, and the gray matter when carefully examined was of a scarlet color in the upper convolutions, and marked here and there with dark spots (ecchymoses) in the lateral convolutions. These dark spots penetrated through the white substance beneath; and the center of the right hemisphere, and especially the corpus striatum,* were entirely disorganized. The posterior lobe of this hemisphere was wholly converted into a greenish-purulent matter which escaped on the removal of the membrane and left a considerable cavity, the sides of which were covered with small pieces of disorganized white and gray matter. The left hemisphere, though much injected with blood, had suffered

* Palsy follows almost invariably on a lesion of this part, which lies beneath the hemispheres.

no disorganization." Here it is evident that the mania had been the result of the inflammation which had at last terminated in gangrene, and which, when it reached the corpus striatum, produced paralysis, of the contrary side as usual. In another case in the same hospital we find a woman after an attack of furious mania gradually losing her memory, till at last she sunk into a state of utter imbecility. She died about seven years after her admission, and on examining the brain, it was found that the convolutions of the hemispheres had entirely coalesced into an even surface, over which a very thin layer of gray matter was spread. The white medullary matter was changed from a soft substance into a strong elastic fibre, which admitted of being torn into long strips, and offered considerable resistance to the knife of the operator.* Examples of this kind might be multiplied from the records of La Salpêtrière, but as they all present nearly the same appearances of inflammation and gangrene, with induration of the white matter if the inflammation has continued long previous to the fatal termination,—it seems needless to quote more. Two other cases of rather a different nature may be added from other sources: the one of a person possessing enough of recollection to be employed in trifling commissions, but idiotic in regard to connection of ideas: whose brain was found on examination to be without the great transverse band which unites the two hemispheres: and a third where, in an idiot girl who died at fifteen years of age, the two anterior lobes, the parts, namely, which form the front of the hemispheres, were entirely wanting: indeed, in all cases of idiocy, the brain has been found exceedingly small in size, and generally

* Pinel, Jun. Physiologie de l'Homme.

but slightly convoluted; for it would seem that this part of the brain only acquires its full size and importance when the cultivation of the mind has called it into activity. In early childhood the convolutions of the brain are very imperfectly developed, and their increase in size goes on simultaneously with the advance of mental power—if this increase be impeded, or if some congenital defect prevent the further growth of the convolutions, the mental powers are of the lowest and feeblest kind;"* and as this important period, in which the organs for future use can be fashioned and enlarged, terminates at about the seventh or eighth year, some notion may hence be formed of the cruel wrong done to the individual if these precious years, in which the future sage or hero is to be prepared for his work, be suffered to pass without culture and without that rational exertion of the higher faculties which alone raise the human animal above the brute. When the brain and the skull can receive no further development, it is late to begin the work of rational education, and he is happy whose mother has not merely sung the lullaby of his infancy, but has laid the foundation also of future greatness, by gently exercising the faculties which call the material organ into exercise without overtasking it; affording it the full play requisite to its development without the unhealthy strain of school lessons while the young brain is too tender to bear it.

41. It would not be difficult to multiply cases where either original imperfection or subsequent injury of the cerebral hemispheres has caused either idiocy or madness; but perhaps a more remarkable proof yet of the office of the brain may be found in the circumstance that† a slight degree of inflammation

* Todd and Bowman's Phys., vol. i. p. 363.
† Solly on the Human Brain, p. 370.

is attended by an extraordinary increase of the vividness of the ideas and the general powers of the mind. In two cases which have been mentioned to me, where I can have no doubt as to the fact, persons previously of rather weak intellect, during an access of what is called brain fever, suddenly acquired a mental force which abandoned them again on recovery; and a friend who has suffered more than once from transitory inflammation of this part has assured me that during the severest paroxysms of pain, the gratification at the immense power of mind thus acquired, almost counterbalanced the suffering.

42. Something of the same kind occurs under the stimulus of wine. A more than ordinary circulation of blood is promoted by it; the brain partakes of the excitement, and the imagination and the emotions are thus mechanically rendered more vivid; but when pushed to excess the vessels become overloaded, and if carried a step further, apoplexy and death ensue. There is indeed no symptom of drunkenness which does not run parallel with those of diseased brain; from the exaltation of faculties in the early inflammatory stage, to the utter senselessness of the fatal termination.

43. With these facts before us, and the* hundreds of others that might be added to them, it would be difficult to avoid the conclusion that recollection and the power of combining ideas, or what are usually termed the reasoning faculties, are as much a function of the hemispheres of the brain as sight or hearing are of the optic or auditory nerves; nor can I better sum up this part of my subject than in the words of the authors already frequently quoted.† "Thus

* Müller, B. III. sec. v. p. 835. Fletcher, Part III. p. 100.
† Todd and Bowman's Phys., vol. i. p. 364.

anatomy leads to the conclusion that the operations of the mind are associated with the convolutions. These parts, in the language of Cuvier, are the sole receptacle in which the various sensations may be as it were consummated, and become perceptible to the animal. It is in these that all sensations take a distinct form, and leave lasting traces of their impression; they serve as a seat to memory, a property by means of which the animal is furnished with materials for his judgments. When the membranes of the brain are in a state of inflammation, disturbance of the mental faculties is an invariable accompaniment, to an extent proportional to the degree of cerebral irritation, and more especially so when the inflammation is seated in the pia mater† of the convolutions. It is plain that in such a case the delirium arises from the altered state of the circulation in the gray matter of the convolutions, the blood-vessels of which are immediately derived from those of the pia mater, so that one cannot be affected without the other likewise suffering. We learn from the most trustworthy reports of the dissections of the brains of lunatics, that there is invariably found more or less disease of the vesicular surface, and of the pia mater and arachnoid in connection with it, denoted by opacity or thickening of the latter, with altered color or consistence of the former. From these premises it may be laid down as a just conclusion that the convolutions of the brain are the *center of intellectual action*, or more strictly, that this center consists in that vast sheet of vesicular matter which crowns the convoluted surface of the hemispheres. Every idea of the mind is associated with a corresponding change in some part or parts of this vesicular surface; and

* The covering membranes.

as local changes of nutrition in the expansions of the nerves of pure sense may give rise to subjective sensations of vision or hearing, so derangements of nutrition in the vesicular matter of the surface, may occasion analogous phenomena of thought, and the rapid development of ideas, which, being ill-regulated, or not at all directed by the will, assume the form of delirious raving. The action of the convoluted surface of the brain, and of the fibres connected with it, are altogether of the mental kind. The physical changes in these parts give rise to a corresponding manifestation of ideas; nor is it likely that any thought, however simple, is unaccompanied by change in this center."

44. It has already been seen that the cerebellum in animals acts as the co-ordinator of movements, so as to rationalize them as it were;—and having now traced the functions of the cerebral hemispheres in man, it is easy to perceive that a more complete organ would be requisite for the execution of its mandates. Accordingly we find the cerebellum proportioned to its work; and the most difficult movements are arranged and executed with the most beautiful precision in compliance with the directing will: yet as the movements which result from thoughts which have previously been propagated through the cerebrum, are in some cases slow, a provision has been made for the safety of the animal by the spinal apparatus, whose nerves act independently of the mind, and whose movements are carried on at times unconsciously, and always without requiring attention. Thus the start which avoids danger precedes the deliberate precaution which might come too late. Whoever has noticed the difference between walking on mechanically, or picking his way for a smooth or clean path, will comprehend

what I mean by the two different kinds of action. In manual operations, too, which are carried on from habit, such as executing a piece of music by rote, the slight pause which occurs if the performer recollects himself suddenly, and turns his attention to the music, shows that thought is slower than the mere habitual action which probably is carried on merely by the nerves immediately in connection, and goes no further perhaps than the segment of the spine in which they are imbedded. Should M. Bouillaud's conjecture that the movements of speech also, are arranged through the medium of the cerebellum, prove well founded—and this is in some degree supported by the case given above (33), where "the answers were slow and difficult," and by the fact that in infants the power of speech is absent while this part remains imperfect,—we shall at once see a cause for its large size as compared with all other parts, excepting those charged with the yet more important functions of thought.

45. We have now traced the machinery by which man is a living, a sentient, and an intelligent animal. We will next proceed to investigate what may be called the elementary functions of intellectual man: and these may be divided into two great classes, distinguished by their causing or not causing bodily change by their exercise. They may be thus arranged in a tabular form.

I. Functions sharing in or causing bodily change:
   1. Appetites and functions appertaining to life—Sympathetic System.
   2. Instinctive emotions—Nerves of sense and medulla oblongata.
   3. Faculties—Hemispheres of the brain.

II. Functions neither sharing in nor causing bodily change:

1. Individual consciousness, including the memory which this requires.
2. Intelligent will.

It cannot be disputed that a vital appetite, such as hunger, or that an instinctive emotion, such as fear or grief, or that the exertion of such faculties as those used in abstract reasoning, are attended with bodily change. Thus, an unsatisfied appetite causes uneasiness; or an instinctive emotion while the body is under its full influence, sometimes acts as an antagonist to appetite, as when grief subdues hunger by deranging the digestive powers. Sometimes the emotion interferes with the most delicate operations of the sympathetic system, as when fear or joy, which necessarily arises from an impression on some nerve of sense, affects the action of the heart through the medium of the connecting links between the spinal and sympathetic nerves; there is then a sensation as of a blow or compression of the chest: or when yawning tells of the general weariness of mind and body. Here a particular nerve acts on the diaphragm, the respiratory muscles are tuned in accordance with this by other nervous fibres connected with it at its origin, and the impulse is propagated through the whole of these muscles. Again, whoever has ever devoted his hours to severe study is most probably well acquainted with the headache and weariness which result from it, showing plainly that bodily organs have been employed in the process.

46. I cannot pass over this part of the subject without drawing from it one useful lesson upon the necessity of cultivating the higher faculties far more than is yet done even among races calling themselves civilized. If the instincts, or as some will call them, *passions*, assume so undue an ascendency in conse-

quence of the inertness of the antagonist part of the brain, that man's whole moral nature falls into the morbid state of a convulsed, or finally a contracted limb, it is then no light crime in those who have the government of a family or of a society of human beings, if they suffer the young to grow up without duly developing the full powers of a nature so admirable where its mental growth is duly proportioned,—so tremendously capable of evil when it is not.

47. A man is not to be considered as educated because some years of his life have been spent in acquiring a certain proficiency in the language, history, and geography of Greece and Rome, and their colonies, or in bestowing a transient attention on the principles of mathematics and natural philosophy; nor is a woman to be considered as educated because she can execute a difficult piece of music in a brilliant style, or speak French, German, or Italian with fluency. Such attainments require little more than mere mechanical recollection,—the lowest of all the cerebral faculties, or the rapid transmission of an impulse from the sensitive optic nerve to the motor ones of the arms and fingers, which is nothing better than the instinctive movement of the animal: neither can the storing up the opinions of others, or the accustoming the tongue to the idioms of other languages, be properly termed an act of thought: for in such cases the capacity of combining ideas, of weighing and judging ere a course of action is adopted, remains even less exercised than in those who, though they are turned into the world with the mind as it were a *tabula rasa* to receive any impression, and too frequently a bad one, yet amid the difficulties and sufferings of poverty, sometimes learn to think. It is from the depths of man's interior life

that he must draw what separates him from the brute, and hallows his animal existence; and learning is no farther valuable than as it gives a quantity of raw material to be separated and worked up in the intellectual laboratory, till it comes forth as new in form and as increased in value, as the porcelain vase which entered the manufactory in the shape of metallic salts, clay, and sand.

48. I have before alluded to the notion of some physiologists that the negro formed but the connecting link between the baboon and man. This has been so fully refuted by Professors Tiedemann * and Owen,† that it is needless to go into it at length; but I mention it here to give a further instance of the necessity of cultivating the mind, even to give the bodily frame its due development, and the duty therefore, which even political economists must acknowledge, of bestowing on all the power of doing so. Dr. Pritchard, in his researches into the physical history of mankind, quotes a fearful instance drawn from the early history of Ireland, of the deterioration consequent on such a degree of poverty and suffering as reduces man to a merely instinctive existence.

49. "On the plantation of Ulster," says the writer, "and afterwards on the successes of the British against the rebels of 1641 and 1689, great multitudes of the native Irish were driven from Armagh and the south of Down, into the mountainous tract extending from the barony of Flews eastward to the sea; on the other side of the kingdom the same race were expelled into Leitrim, Sligo, and Mayo. Here they have been almost ever since exposed to the worst effects of hunger and ignorance, the two great brutal-

* Phil. Trans., 1836, p. 497, &c.
† Trans. Zoo. Soc., vol. i. p. 368.

izers of the human race. The descendants of these exiles are now distinguished physically from their kindred in Meath and in other districts where they are not in a state of physical degradation. They are remarkable for *open, projecting mouths,* with prominent teeth and exposed gums. Their advancing cheek bones and depressed noses bear barbarism in their very front. In Sligo and the northern Mayo, the consequences of two centuries of degradation and hardship exhibit themselves in the whole physical condition of the people, affecting not only the features, but the frame, and giving such an example of human deterioration from known causes, as almost compensates, by its value to future ages, for the suffering and debasement which past generations have endured in perfecting the appalling lesson. Five feet two inches on an average, pot-bellied, bow-legged, abortively featured, these spectres of a people that were once well grown, able-bodied, and comely, stalk abroad into the daylight of civilization, the annual apparitions of Irish ugliness and Irish want. In other parts of the island, where the population has never undergone the influence of the same causes of physical degradation, it is well known that the same race furnish the most perfect specimens of human beauty and vigor both mental and bodily."

50. If such be the effect under our own eyes of reducing man to the lowest point at which he can maintain even a mere animal existence, we may well believe that ages of such a state may have stamped many of the characters of the brute creation on the human countenance in the wilds of Africa. The great difference between the skull of the negro and the European consists in the wide opening for the nose, which by its greater spread affords more room for the development of the olfactory nerve; and we

may add to this, the form of the jaw again approximating to the animal in its projection, though not in its other characters. We may probably read in these peculiarities the history of generation after generation doomed to a merely instinctive existence, as well as we read sensual indulgence in the thick, moist, swelled lips which so frequently characterize those who give themselves up to such a course of life.

51. It is almost needless to observe, after what I have already said, that it is to the surplusage of fibres in the brain over and above the quantity requisite for the transmission of sensation to the appropriate motor fibre, that we must trace not only the power of reasoning, but all the finer flights of imagination and wit. The agent of which I shall now presently have to speak, appears able at will to reproduce the impressions once received through the medium of the nerves of sense, and it is amid the novel combinations of the fibres thus called into action, that all those wonders of thought are produced which have won our admiration through all ages. That such is their origin may be proved by the fact, that the most brilliant imagination never yet produced anything which had not been seen, heard, or felt, as it were piecemeal: the combination is new, but the material thus woven afresh is what all are acquainted with.

52. We have now traced the human animal through all parts of his structure: we have shown first a system of ganglia and nerves springing from them, by means of which organic life is carried on, and appetites excited for its maintenance: we have further seen a set of nerves whose terminations are to be found at the base of the brain, which supply the senses by which man communicates with the exter-

nal world: we have seen another apparatus within the cranium by which these sensations are weighed and examined, and the result of this examination transmitted finally to the motor nerves for execution; altogether forming the most perfect piece of machinery ever constructed: for these nice operations of thought are the work of fibres and fluids contained in them merely set in motion by the impression made at one part, and thus transmitted through the whole series. Let us now consider the actions of this animal.

53. The first instinctive impulse is to preserve life. Look at a wrecked vessel! There is one man there ordering and directing all on board: the only remaining boat is lowered; he is careful to see it filled with the persons crowded about him,—it pushes off, and where is he? He is there on the deck of that sinking ship; the boat would not hold *all*, and he has refused a place in it, and remained to perish rather than sacrifice one life committed to his charge. He knows that death awaits him: he has been urged to save himself, and yet he is there! What is the impulse which prompts him thus to contravene the first great law of animated nature?

54. Sleep again is among our most imperious needs, for the want of it gradually destroys life. There lies a sick man in his bed, senseless,—in the last stage of an infectious fever: and there is one watching beside him, looking pale and exhausted, but who sleeps not, stirs not, though her young life is wasting away with fatigue, and exposed to contagion: and she knows it, and has calculated that the same grave will receive both! What nerve of all that fine machinery has impelled her to this course?

55. Look at the Astronomer in his observatory! The night is far advanced, and he is chilled and

fatigued; yet he remains with his eye at the telescope—for what? To carry on a series of observations which perhaps in two generations more may give as its result the knowledge of some great law of the material universe: but he will be in his grave long ere he can expect that it will be ascertained. He sits down to his calculations, and he forgets his meals, sees nothing, hears nothing, till his problem is solved! No sense prompts him to this sacrifice of rest and comfort. But do we call these persons insane? No—we honor them as the excellent of the earth: admire their lives, and wish that when the occasion comes, we may have courage so to die.

56. I know but of one solution of the difficulty; there must be some element in man which we have not yet taken account of; some untiring, undying energy which eludes indeed the fingers and the microscope of the anatomist, but which exercises a despotic sway over the animal mechanism and takes possession of it for its own use, to the point of exhausting and finally destroying it. Nor is it any objection to this view, that there may be instances either of congenital idiocy or subsequent injury of the brain, where this power is less manifested; for we are not wont to judge of the peculiar characters of a species from the anomalous exceptions. The power which overmasters and despises sense is yet obliged to convey its mandates through bodily organs; take these from it, either wholly or in part, and it can no longer manifest its existence in the same way as when these organs were perfect. The paralytic man would move his arm or would express his wishes if his arm or his tongue would obey him; and his frequent impatience at their incapacity sufficiently shows that the ruling will and the servant

faculties are of a different and distinct nature: nay, it has been observed that even the insane are at times conscious of and lament a state of brain, which no longer enables the individual to act rationally. This could not occur, were the brain and nerves as acted upon by external stimuli, the only spring of man's will; for then the altered structure would invariably produce a satisfied acquiescence in its results.

57. It will easily be seen that if we acknowledge a distinct acting principle in the above cases, we cannot in any other involve it in the accidents of the body: in sleep it voluntarily abandons the senses to the repose they need, and resumes the use of them when it chooses, for who does not recollect how, when the weary body required repose, he has *forbidden* thought, in order to allow the senses to fall into the state of torpor necessary to recruit their vigor? And there are few, probably, who have not also experienced how easily sleep, which would otherwise have lasted for a much longer period, may be curtailed by the resolution to awake at a particular hour. In death,—whatever be the cause that exhausts the muscular irritability so far as to make it no longer sensible to the usual stimuli, the cessation of that living action at once stops the machine. It is in vain that the musician touches the keys, if the strings be broken; but we do not thence argue that the musician has ceased to exist; nor have we more reason to conclude that the principle which claimed the powers of the living body for its own use, has ceased to exist, because the instrument it required to make its presence apparent is out of order or destroyed.

58. The philosopher, when he sees an effect produced, seeks for the cause: the chemist, if he finds

two apparently similar substances which under the same test exhibit different phenomena, thinks *that* a sufficient cause for considering them different in nature, and gives them separate names. If, then, effects occur in man which are not sufficiently accounted for by any known bodily organism or impulse—if under the same circumstances he acts as no other animal would act, we must either on this occasion throw aside all our usual modes of reasoning, or we must pronounce that man differs essentially from all other animals, and has a cause of action not to be sought for in nerves and muscles. That cause may be invisible; so is the wind: imponderable; so is electricity: intangible; so is light, if the one organ fitted to receive it be disabled: it is therefore no new thing to find an existing agency of potent efficacy which as far as regards our senses is invisible, imponderable, and intangible. What we call it, matters not; it is evidently superior to, and master of the body: it has other objects in view, other pleasures, other hopes; and to attain these it compels its slave to undergo privations, pain, and death.

59. I have already referred to the table where the phenomena of man's nature are reduced to two classes: those whose exercise either causes, or is attended by, bodily change, *i. e.*, emotion, fatigue, or painful exhaustion—and those, which though incessantly manifested, produce no sense of weariness whatever. It is certainly among the last of these that we must look for this unknown and potent cause: accordingly we find, that the two unchanging functions noted in this table are exactly those which would give rise to such actions of the human animal, as I have described. These functions or attributes are, a consciousness of individuality independ-

ent of the bodily frame, which talks of the limbs and the faculties as *its property*, not *itself;* and an intelligent and indomitable will, forming an essential attribute of that individual existence. It is this persevering and remembered will, acting frequently in opposition to the animal nature, which it is my object to claim as the distinguishing characteristic of man; as the manifestation of another nature, differing in attributes from and superior in energy to the mere bundle of muscles, nerves, and blood-vessels which we see before us, and which it rules so despotically. A moment's reflection will show us, that the memory inseparable from the exertion of this individual and intelligent will, is perfectly distinct from that faculty of common recollection with which it may at first be confounded. This latter, like all the other faculties of *the brain*, has its infancy, its maturity, and its decline; is strengthened by exercise, impaired by disease, enfeebled by entire repose; but the memory necessary to individual consciousness and will, is perfectly insusceptible of fatigue, increase, or diminution; and when palsy or age has taken away the recollection of persons, of events, and of words even, the memory of individuality requisite to the exertion of will remains as strong as ever; and the impatience usually attendant on such a state is perhaps one of the strongest proofs, that the organs are the servants, not the cause, of the intelligent will.

60. We have already seen how far the volition which is the result of a shock sent through the nervous circle can go: it amounts to little more than a blind instinct, for the animals which possess this apparatus in common with man, are incapable of education beyond a certain point, and that education is only to be effected by the fear of pain or expectation of food. The poverty of language is always a

great hinderance in philosophical researches, and here it is particularly felt; for we have but one word to express this instinctive will of the animal and that lofty prerogative of man which defies the influence of sense, despises the small globe it inhabits, roams over space to find objects great enough for its contemplations; and amid worlds upon worlds which multiply on our view as art prolongs it, still feels dissatisfied, and requires nothing less than infinity for its contemplation—immortality for itself.

61. If we look through nature, we shall find that the happiness of the organized being consists in the accomplishment of its end of existence. Animals, while supplied with food, and propagating their kind, are happy: their span of life is long enough for all the enjoyments they require: but man's life is insufficient for his wishes, and these gross pleasures disgust and weary him. Where is *his* happiness, then? We have seen it! The captain of the wrecked vessel feels his heart swell with proud delight as he awaits death with a consciousness of having done what, if he were an animal only, would be an act of the wildest insanity. The fair girl, before whom all the pleasures of life were smiling, despises them, and finds her joy in dying with the object of her affections, because she *feels*, even if she does not argue, that thus they will still be united. The astronomer has no greater delight than to pursue knowledge which affords him neither fame nor profit; though it be only to be gained at the expense of fatigue at any rate, and probably of health.

62. These are the pleasures of a being whose nature has other ends than that of merely spending seventy years in eating, drinking, and sleeping, in the pleasantest way, and leaving other beings so to eat, drink, sleep, and—die! Nor is it merely a few

that thus feel: the consciousness of a higher destiny is so rooted in man, that even the savage brands *him* with disgrace who seeks to preserve life at the expense of what he may deem honor, and the name of a coward is the worst of reproaches. There is scarcely any cause so slight that man will not risk his life for it: can we then with any common show of reason assert that sensation alone is *his* source of action? That risk of life brings no pleasure unless it be a mental one: he rises in his own esteem by so doing, and, it may be, in the esteem of others; but he does so only because, by despising base life, he has made good his claim to a higher nature.

63. We have asked, what is man's destination? I reply from these facts—immortality. We have asked, what is the ultimate object of his existence? I am not here allowed to enter on the higher ground which would make the chain of reasoning complete; but if we allow that this rare piece of mechanism is not created by the cause that impels it; and no *man* has yet succeeded in imitating the smallest portion of organized matter; then a higher intellect must have produced it, and I can hardly be wrong in assuming that the intelligence which planned such a scheme of being, planned it not in vain; and that man is not the sport of circumstance, filled by his very nature with evil desires which it is his business to uproot: but that the invisible essence, which we have found so decidedly manifesting its existence in the midst of its bodily trammels, is placed in such a situation as to be improved, not deteriorated by, the companionship. He cannot alter the function of one fibre of a nerve even; it would be tyranny were he called upon to do so; but he can regulate and balance their action, and find those very functions which he can never alter, those very propensities

which he can never subdue, because they are requisite to his existence as an animal,—sources of enjoyment and of virtue.

64. I am forbidden here* to enter on the nature of the only other intelligent will which we have any cognizance of, but this much I may be allowed to say,—that like natures must have like enjoyments. We have seen that all animated nature seeks the end of its being, and is happy in attaining it: if man then be akin to that ruling will which both he and the universe own as Lord, the ultimate object of his existence must be a like happiness, and we can figure none to ourselves for such a being but pure benevolence and perfect knowledge. Let me here be allowed to borrow the words of a philosophical writer to whom I am already indebted for many of the views I have this evening propounded: I can hardly give a better summary of the practical results of the whole system. "Thus," says the writer, "we see two kinds of animal functions mutually balancing each other, uniting to school the individual will to all that is amiable and exalted; the instinctive emotions softening the sternness of the faculties; the faculties curbing the animal force of the emotions: and the will, impelled by the solicitations of the one, and guided by the information and caution of the other, acquiring by degrees those habits of judging and feeling rightly which qualify man for the spiritual felicity of his Creator. He has learned the enjoyment of benevolence and the excellence of knowledge, and his heaven is already begun on this side the tomb; and thus, though these emotions and these faculties may cease with the bodily mechanism which

* The rules of the Royal Institution confine the lecturer to scientific subjects.

causes them, they have stamped their impress on the individual. Like metal poured from a furnace into a mould, which retains forever the form so acquired, though the mould be but of earth; the soul has acquired the character it will carry with it into eternity, though the mould in which it was cast be returned to its dust."—*Philosophical Theories and Experience*, p. 74.

THE END.

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